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VOLUME I, NO. 4 DECEMBER 1949

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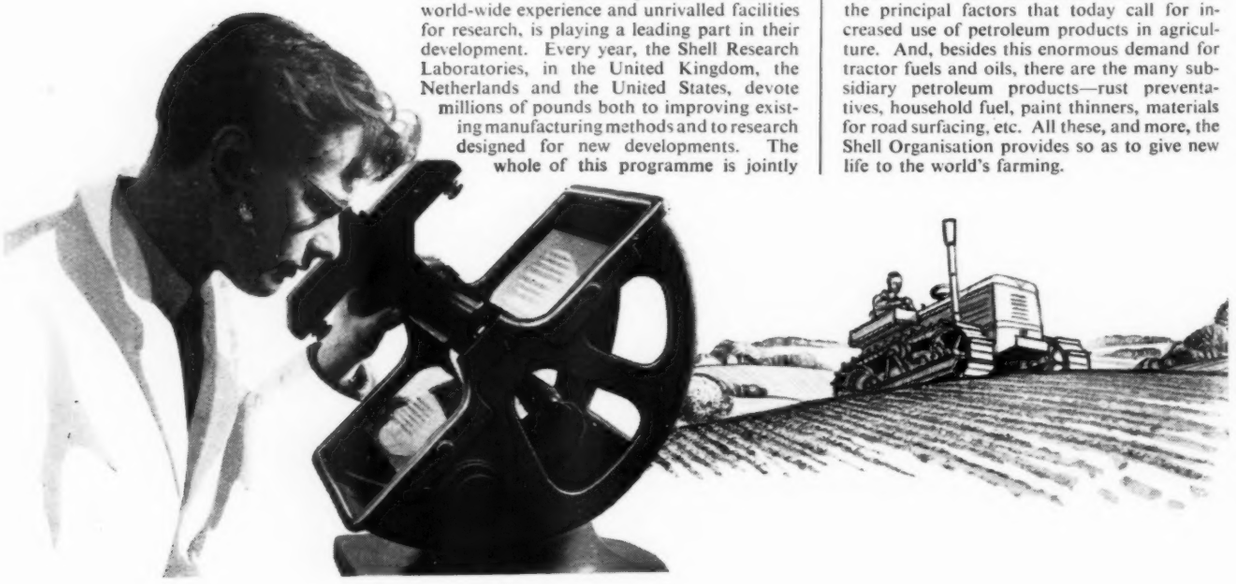

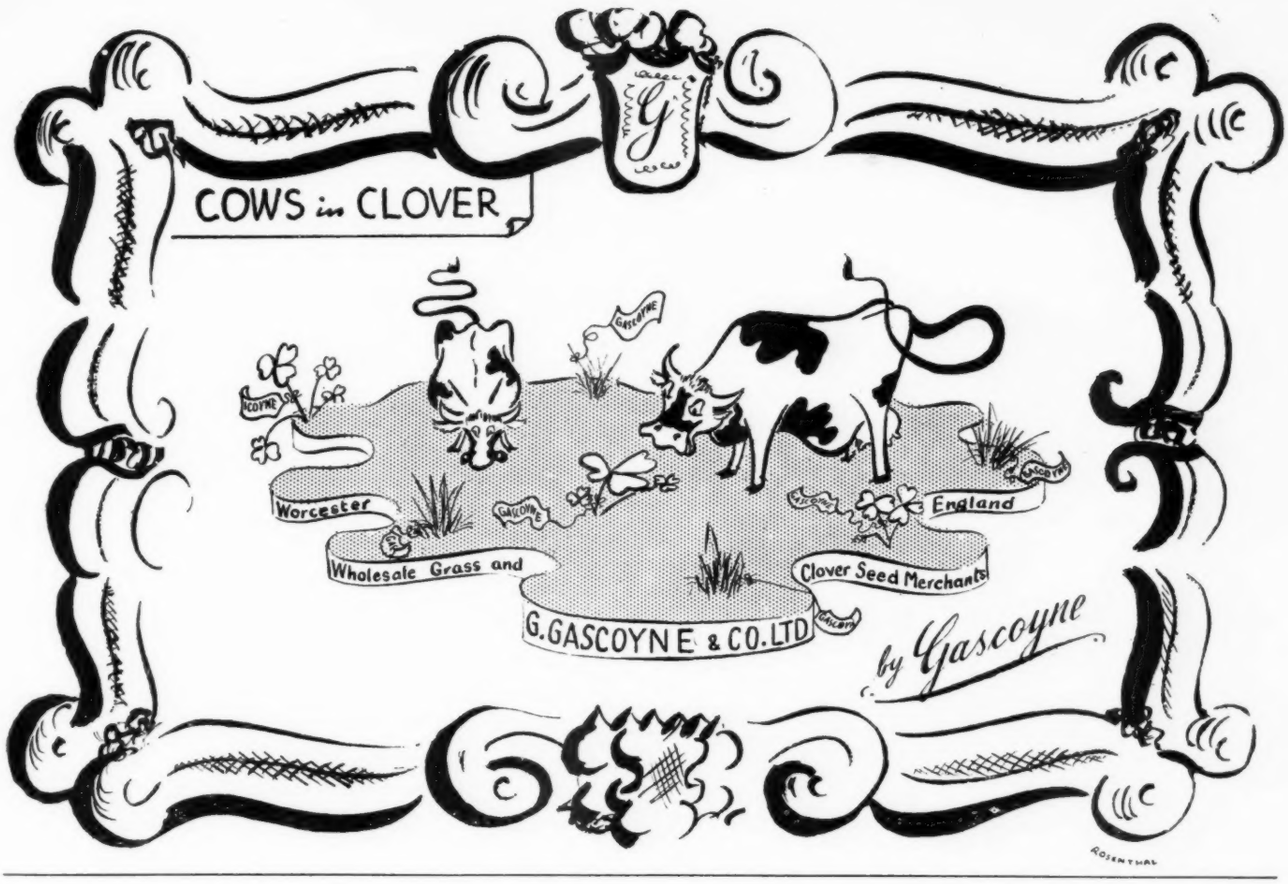

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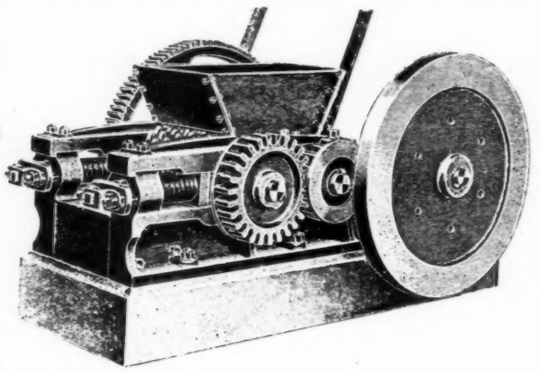

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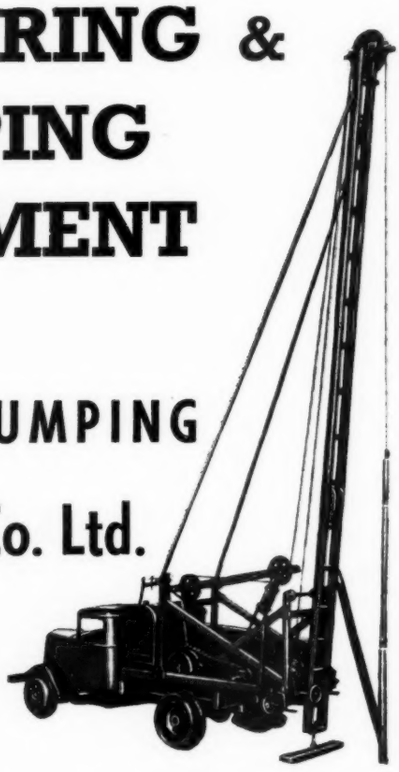

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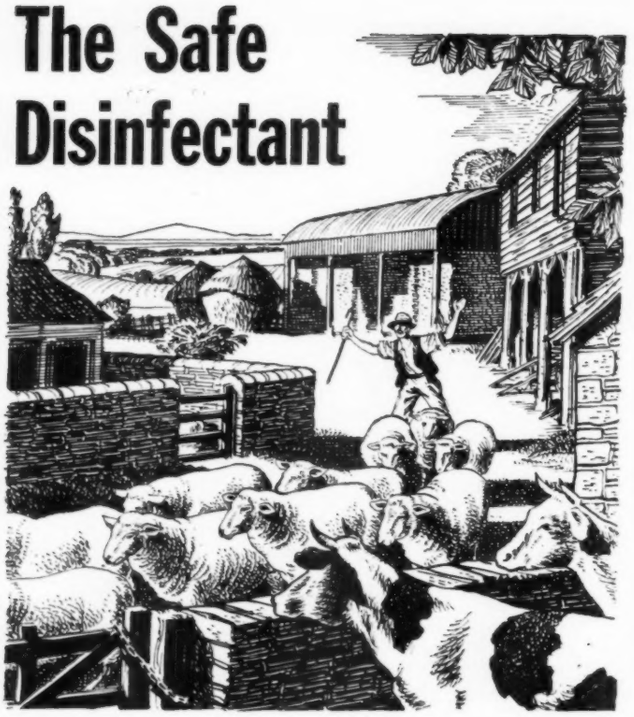

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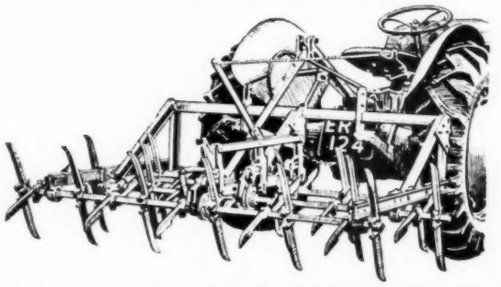

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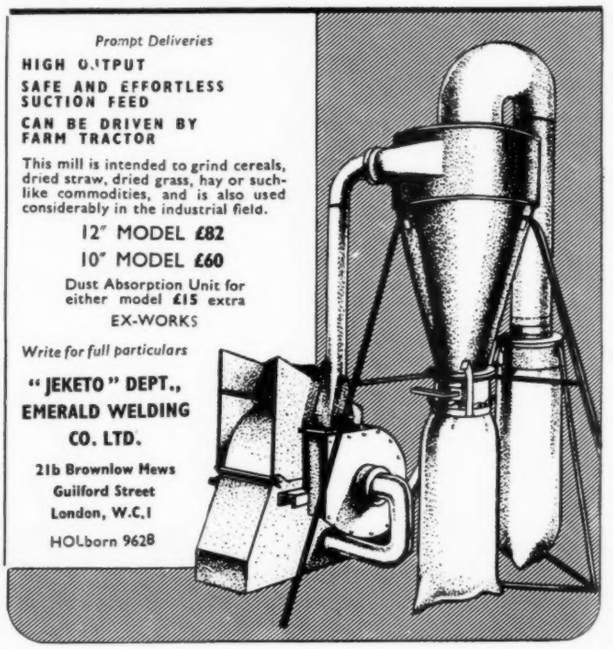

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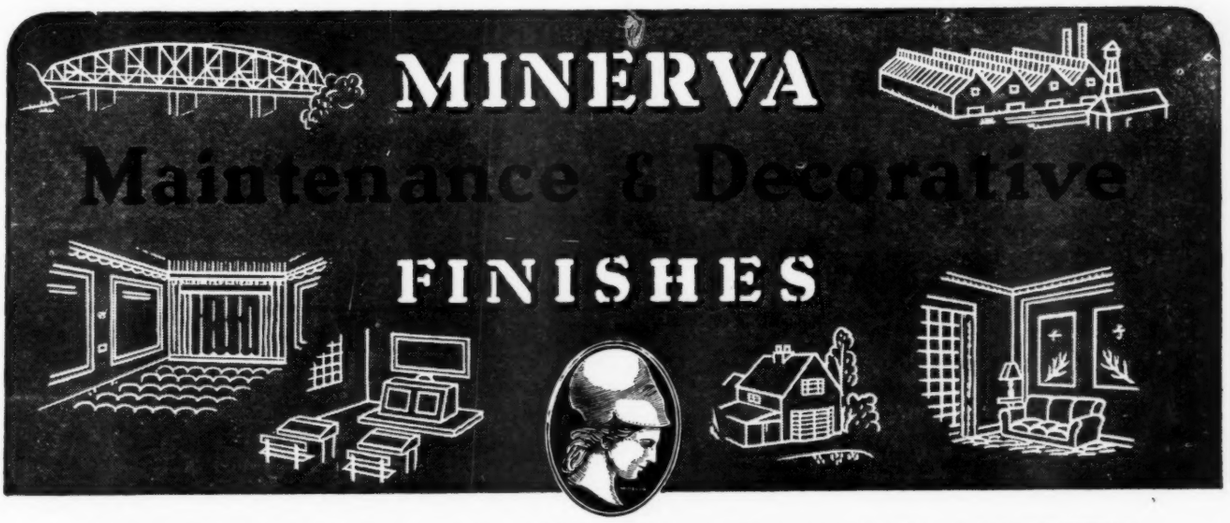

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THIS MONTH'S COVER

Sugar, with the help of American capital, has become one of the biggest industries, and the chief money crop of Puerto Rico. At this time of the year the cropping season is just beginning and runs through until May. Hand cutting is still the principal method of harvesting, and the cane-cutters put in long hours of hot, hard work.

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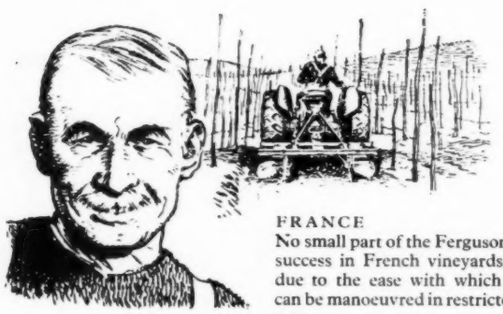

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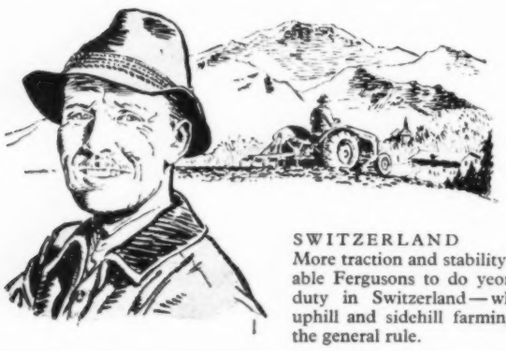

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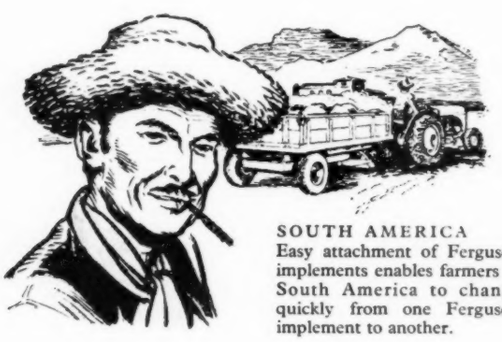

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Editorial Comment

Inquest on groundnuts

THE publication of the First Annual Report and Statement of Accounts of the British Overseas Food Corporation has aroused widespread public interest. This is to be expected in view of the publicity which has been given to the project, the magnitude of the expenditure, and the smallness of the practical results so far achieved. It is unfortunate, although perhaps inevitable, that the scheme should to an extent have become a counter in the political game, since this must obscure and colour judgment on a matter which should be considered purely objectively.

At the outset two general conclusions on principle appear to us to emerge after a perusal of the report :

(1) It is a mistake to imagine that large-scale agricultural development can be undertaken with prospects of success if the natural factors which condition production are not fully known at the outset. If they are not known provision to ascertain them is an essential preliminary. It may occupy a number of years, but in its absence any scheme for development must at best be a highly speculative venture.

(2) There is a limit to the speed at which developments can be undertaken, especially under rough and primitive conditions ; up to a point it may be capable of acceleration, but ultimately a limit is reached when no extra expenditure on equipment, staff and labour can bring a commensurate increase in the rate of development. The law of diminishing returns, in fact, operates just as forcibly in this connection as in any other.

It seems that at any rate part of the difficulties the scheme has encountered may be due to initial failure to appreciate these principles, and that the 'splendid vision for Africa,' which the report now candidly admits was beyond the attainment of a new organisation, may have so dazzled the authors of the White Paper that they were unable to perceive their cogency.

The need for pilot trials . . .

When manufacturing undertakings develop new processes the standard procedure is first small-scale experiment combined with thorough examination of the underlying physical and economic conditions, followed, if the results are satisfactory, by commercial trials on a limited scale—the pilot plant—followed, again if the results warrant it, by full-scale development. If this technique has become standard on the manufacturing side, *a fortiori* how much more necessary is it in agricultural development where the factors which determine success or failure are so much more numerous and the uncertainties and risks so much greater ? Actually it is only by proceeding along these lines that the spectacular success of the Sudan Government working with the Sudan Plantations Syndicate in developing cotton cultivation in the Sudan Gezira, has been achieved, or, on a parallel although less formalised scale, that the great plantation rubber and oil palm industries of the Far East have been developed.

. . . and the effects of their omission

By deciding 'to proceed immediately and in a headlong manner,' as the report itself puts it (p. 10), the Corporation disregarded these considerations ; they were impelled to do this (so the report indicates) by the critical world shortage in 1946 of oils and fats, but for the expenditure of a sum which must be altogether unparalleled in the history of plantation agriculture, they had only succeeded by March 31, 1948, in clearing a total of 28,000 acres as against the initially projected estimate of 300,000 acres, and by March 31, 1949, in planting 46,000 acres at Kongwa and 2,700 acres at Urambo. To cap these failures in the latter year practically the whole crop was apparently lost through drought.

It seems apparent that the hopes underlying the original conception that by proceeding in this manner it would be possible rapidly to augment the world's supplies of vegetable oil were, in fact, illusory.

It is a somewhat melancholy reflection that if a tithe of the millions which have been spent had been devoted to reconditioning the railway in Nigeria, where some 300,000 tons of groundnuts were lying immobilised owing to lack of rolling stock, the available supplies of groundnuts would have been greatly augmented.

Justification for expenditure

The report seeks to justify the expenditure by pointing to the valuable experience gained which, it is claimed, will enable further developments to proceed with much more certitude. It is also claimed that as a result of it much valuable equipment has been acquired which it would have been impossible to procure later on. It is certainly true that much valuable experience has been gained but if a proper programme of experiment had preceded development the same result could have been achieved and vast sums could have been saved—it is, indeed, possible to buy experience too dearly. In regard to the second point various statements in the report make one wonder whether it may not be

doubted if the whole of the equipment so acquired was really entirely suitable for the purpose in view.

Research results

To us the most interesting and valuable section is the Scientific Report for 1947-48, which forms Appendix V. It shows how a small team of scientific workers with their feet well on the ground, working under conditions which must have often been incredibly difficult, supplied answers to some (although of necessity not all) of the problems that arose, in a relatively short space of time and gave effective guidance on policy. The following paragraph from the Report seems to us particularly apposite. Referring to possible rotations at Kongwa it is stated that ' it seems better to concentrate first on determining the correct cultural conditions . . . for a range of possible crops, by intensive experimentation. . . . The policy of the Department views the development of systems of farming suited to the . . . various regions as the ultimate objective. The composition of rotation sequels will develop naturally from this.' Such methods take time but it is the only safe way to proceed. Again in relation to the inclusion of livestock in the rotation the Report wisely remarks : ' Livestock are unquestionably needed . . . but it would be most dangerous to apply preconceived notions derived from experience in temperate or even subtropical climates to fully tropical and semi-arid conditions in Tanganyika without sound experiments and full proof that the proposed system would succeed.'

Sunflowers as a substitute

From the Report and from earlier statements in the Press it has apparently been decided largely to replace groundnuts by sunflowers on the lands at Kongwa. Sunflowers were envisaged as a possible alternative crop to groundnuts in the original proposals of the White Paper, but the experimental trials so far recorded, meagre though they are, do suggest that the outlook for this crop may be at least as uncertain as that for groundnuts. The variety trials show greatly fluctuating yields, while apparently variation in the time of planting by as little as ten days can reduce the yield of the same variety from 1,300 lb. per acre to as little as 200 lb. per acre. It would, indeed, be a bold private company which would embark upon the development of any crop on such evidence as this.

The Southern Highlands

The Southern Highlands will eventually be the largest part of the scheme and the developments there envisaged are on a considerably larger scale than those at Kongwa and Urambo. Considerable expenditure has already been incurred on port, railway and pipe-line developments, but so far as exploring scientifically the agricultural potentialities is concerned, little has apparently been accomplished. It is admitted that the area is imperfectly known and little reliable topographic work has been done. Apparently some 2,800 acres have been cleared and 564 acres planted experimentally under a variety of crops including groundnuts, maize, sunflowers, castor and sorghum, but no details are given of the type, size or scope of the experiments. It would also seem that only a very cursory reconnaissance of the soils has been possible and only a small number of analyses had been carried out in 1947-48. It may be that the number has since been extended. The meteorological data for the area are also very limited. In view of the preceding events one would have thought that it was obvious that intensive examination of the soils-vegetational climatic complex coupled with carefully planned experimental work in the Southern Highlands was a first priority, if past experiences are to be avoided.

It is clear that, for example, if the results of the pedological work on the Kongwa catena had been available at the outset, the attempt would probably never have been made to cultivate those lands. To neglect similar precaution in regard to the Southern Highlands seems to be inviting an unnecessary risk, and to show unwillingness to profit from the experience of the past.

There is, moreover, the undoubtedly serious threat from rosette disease which, it is stated on p. 122, in the Southern Highlands is certain to be a major problem. Surely extensive experiment to investigate all these matters ought to precede any full-scale development ?

Muddle with money

It is disquieting also to read in the financial statement that the Company and some of its contractors did not find it possible to maintain for all aspects of their operations the proper books and accounts necessary to give a true and fair view of the state of the Corporation's affairs, and that there were many instances where documents in support of transactions recorded in the books were not produced to the auditors. No doubt this too, is a product of the decision to ' proceed in a headlong manner.'

The outlook

What of the outlook ? Obviously the vast expenditure already incurred and the experience gained (the fact that it has been needlessly expensively gained does not detract from its value) make it unthinkable that it should be wasted, particularly having regard to the enormous and urgent problems presented by Africa.

Little is said in the report as to future development policy, but apparently the inherent intention is to proceed with development on much the same lines as in the past with the same objective and very similar methods. It is, however, to be borne in mind that the problem of supplies of vegetable

oils which was the immediate cause for the inception of the scheme, is no longer of such immediate mondial urgency, although it is still urgent in Great Britain owing to the currency difficulty. On a longer view it is also likely to become increasingly urgent as world populations increase, but growth will be gradual and, as was argued in an article in the first number of this journal, the most rewarding way of dealing with the problem lies not in the extended cultivation of annual oil seed crops but rather in the more extended cultivation of perennial oil seed tree crops such as oil palms and coconuts, which, though they take several years to reach the bearing stage, give much higher yields of oil with much less labour.

To us it seems that this consideration must dominate future policy and that the main problem now is not so much to pursue the original objective with unabated vigour, but rather to consider how far it is desirable to modify and perhaps to reorientate the scheme to meet changed conditions and to fit it into the general policy of African development.

It was inherent in the original proposals that the scheme would ultimately evolve into one in which the African is integrated into some form of partnership in the enterprise. No details of what was envisaged have yet been made public but it seems to us that the time may have now arrived when this aspect also must be considered.

To conclude, we suggest that the scheme should be overhauled, its objectives re-considered and re-defined and its whole development reorientated. In doing all this full use should be made of the best available scientific, administrative and economic advice. Only by working in this manner can the scheme hope to bear anything like the fruits which can rightfully be expected from the expenditure of so much money and effort.

Agricultural instruction

IN his presidential address to the Agricultural Section of the British Association last September Prof. N. M. Comber pointed out that, although agriculture itself is an art, like other arts its practice can be greatly aided by the application of science to its various problems. Oft-times, however, the research specialist is not fitted to perform the task of communicating the results of research to practising farmers and this duty can best devolve upon advisory officers specially trained for the job and with actual farming experience. It is essential that they should be in close and continuous touch with the specialist, while the specialist himself, if his work is to be effective, must be sufficiently aware of and acquainted with the practical aspects of problems and conditions of the practising farmer. On this account he deplored the step recently taken in Great Britain of separating the agricultural advisory services from the agricultural colleges with which formerly they were associated. Prof. Comber's remarks referred primarily to Great Britain, but they have an almost world-wide application.

Insofar as the British Colonial tropics are concerned, particular interest attaches to the work of the Imperial College of Tropical Agriculture, the last annual report of which we review on another page. The College on the teaching side plays an essential part in the training of the senior agricultural staff of the whole of the Colonial Dependencies and also provides a three-year diploma course which is largely used for the training of local agricultural staff for various West Indian Colonies. The College has always carried out a considerable programme of research and has assisted local departments of agriculture with advice; the recent enlargement of its functions to include four research schemes of major importance which apply to the West Indies as a whole causes it to become in fact, if not as yet actually in name, an agricultural research institute for the whole of the West Indies. This combination of functions under the complicated administrative set-up of the West Indian Colonies provides a practical pattern of regional development in which research, higher teaching and extension work are closely associated.

A noticeable point is that the curriculum for senior students now includes instruction in methods of agricultural extension work, thereby ensuring that all agricultural advisory staff throughout the Colonial Dependencies will in due time be informed concerning the practice in this regard in many lands and so be placed in a position to apply the results of experience to the solution of their own particular extension problems.

For many years the Imperial College was the only agricultural training establishment of university status in the Colonies, but recently there has been a strong move towards the establishment of University Colleges which, it is anticipated, will be the precursors of Universities in other groups of Dependencies. They must necessarily have strong agricultural faculties and the experience gained at Trinidad should prove invaluable in connection with these developments. Indeed, consultations are already in progress to ensure that full advantage is taken of this and it is understood that further regional consultations are contemplated.

Coffee production

THE article on the East African coffee industry which appears on another page naturally excites speculation concerning the future market prospects for coffee. The dominating factor has long been production in South and Central America, and notably in Brazil, which in itself supplies about half the world's demands.

A recent article in the London *Times* gives some information on the present position of the Brazilian

industry. The ruinous competition between the various Latin-American producing countries has now been effectively halted as a result of the creation in 1940 of the Inter-American Coffee Bureau, which inaugurated a system of international control over production; Brazilian production, which during the decade before the last war averaged 22 million bags annually, has since the war ranged between 13 million and 17 million bags, and following this trend Brazilian supplies, which formerly accounted for 70% of the world's exports, have been reduced to 48%.

As a result the stocks of Brazilian coffee, which weighed so heavily on the world's markets, have now, it is believed, been practically liquidated, while, in the meantime, world consumption has appreciably risen.

It seems, therefore, that, despite the opening up of some new high-yielding areas in the Parana province of Brazil, it is unlikely that there will be a repetition of the disastrous over-production that was so deplorable a feature of the 1930s, particularly as declining yields are occurring in other localities due to ageing of the trees and soil deterioration.

The East African coffee industry, compared with that of Latin-America, is small. Moreover, the product of East Africa, which consists partly of 'mild' arabica coffees and partly of native-grown robusta 'hard' coffee, is in a somewhat superior class to the Brazilian coffees, which are stronger in flavour and more bitter. Nevertheless, Brazilian coffees dominate the world market by virtue of the magnitude of their production, the position in this respect being not dissimilar to that of West African production in regard to the cocoa industry.

Small by comparison as the East African industry is, it is nevertheless growing considerably. Current production is in the region of 70,000 tons annually; in 1930 it was 28,000 tons, and it has thus considerably more than doubled in the space of 19 years. Some control over production is assured by the system of controlled marketing, which is at present in force as a sequel to the establishment of the war-time controls.

The industry has made extensive provision for research, which is bearing substantial fruit, and the continued linkage of this with efficient provision for regulating production and marketing seems essential for future stability.

The Brazilian industry has also recognised the need for research, impelled thereto by declining yields from the older plantations; a well-equipped research station has been established at Campinas and it is becoming increasingly appreciated that the provision of a greater degree of scientific assistance to cultivation and production is essential.

In this regard, therefore, there is a parallel between the East African and the much larger Brazilian industry. In another respect there is also a close parallel, namely, in regard to labour, which on estates in both territories is becoming increasingly scarce and costly. In East Africa this appears to be translating itself into extending production on native smallholdings, in connection with which it is noteworthy that there is an apparent willingness to submit to a certain degree of overall control to safeguard and improve production.

So far as market prices go, therefore, the outlook for coffee seems reasonably assured, but in other directions there are many problems. Is it too much to hope that in due course a *rapprochement* may take place between the producers in the Western and the Eastern Hemispheres which will assure the collaboration of all interests on a mondial basis and which alone can provide the only firm assurance of a stable position?

Availability of fertilisers

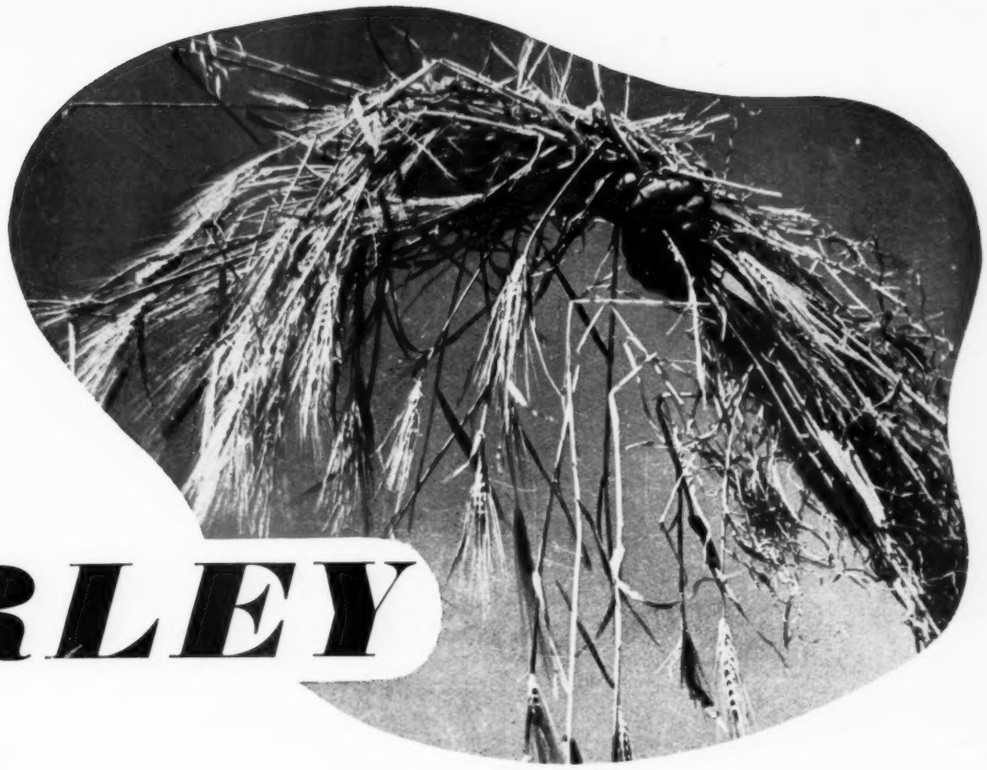
AVAILABILITY to the plant of fertilising elements in manures is a problem which has exercised the attention of chemists for generations. Progress has been achieved in regard to the mineral elements phosphorus and potash, although controversy still surrounds the former.

It is curious, however, that hitherto little attention has been devoted to the third and most important plant nutrient, nitrogen. It is, of course, a commonplace that artificials such as sulphate of ammonia and the various nitrates are readily available and quick acting, while the organic manures are less so and much more slow in their effects.

However, there have been few attempts to discriminate between, and to give numerical expression to, the availability of nitrogen in the different members of the latter class. It has long been known that the availability of nitrogen in dried blood is much greater than in materials such as leather waste, hoofs, horns and hair, but little has been done to attempt to give numerical values to these differences.

On this account a recent paper delivered by Dr. J. Hubert Hammence to the Agriculture Section of the British Society of Chemical Industry is of interest, since it indicates a method which may prove of considerable value to the chemist and through him to the practising farmer. The method depends on using dried blood as a standard and comparing other materials with it when applied in the laboratory to the same soil. It would be out of place here to enter into details, but the method and the results obtained by it so far indicate that it may possess considerable potentialities. For example, it would be of assistance to a farmer if he could be sure that an organic manure that he applies to his fields and which shows on analysis a certain content of nitrogen is really likely to benefit his crop and what would be its relative efficiency or, conversely, that it is really of little efficacy on account of its low availability. There seems to be some hope that this desirable end is now within sight.

World Cereals Today



BARLEY

G. D. H. BELL, Ph.D.
School of Agriculture, Cambridge

Barley, the fourth of the major cereals to be considered in this series of articles, is no longer of great importance as a human food, and is used chiefly as a livestock feed and for malting. Although it can give high yields of grain in a comparatively short season, low standards of agriculture have resulted in consistently poor crops in large areas where it is grown. The problem, as discussed in this article, is not only to raise yields by all means possible, but also to eliminate the lean years in the areas subject to the greatest hazards and fluctuations.

OF the 100 or so different botanical forms or groups of barley, only 10 occupy a prominent position in world agriculture in that they contribute together the bulk of the world crop, while three of these 10 are of much greater importance than the remainder. These botanical forms, which are of course quite a distinct consideration from the many thousands of named agricultural varieties, are significant because their ecological requirements determine the distribution of the barley crop and the occurrence of distinct botanical types under any given set of conditions.

The three botanical forms of the greatest importance are those which have lax pigmentless ears with grain adherent to the husk, but the ears may be of the six-row or two-row type, and the beards or awns may be toothed or smooth. These forms dominate the more temperate regions of the world and have the widest distribution in the most important barley-growing areas, although other botanical forms are peculiar to certain areas in the Far East, India, North Africa, Abyssinia and certain other parts which have special requirements owing to climatic conditions. But it is possible to recognise large geographical groups of cultivated barleys such as the European, Asiatic, African and American, with more restricted and ecological races, within the continents, which are confined to certain areas, countries or local climates. It is within national boundaries that the vast number of named and unnamed agricultural varieties have been developed which have done so much to increase production by means of higher yields and extending cultivation of the crop to new areas.

Important areas of cultivation

Although it is in the temperate regions of the northern hemisphere that barley has been most extensively and successfully developed as a farm crop, there is a wide range of conditions where it is grown. Barley excels as a high yielder of grain in a comparatively short growing season and is, therefore, predominantly grown as a spring crop, although there is sufficient winter-hardiness in some forms to enable winter crops to be taken safely where the climate is not too severe. These characters, combined with the ability to ripen successfully under comparatively high temperatures, give barley a distribution which includes areas as far north as any cereal can be cultivated and as far south in Europe as the Mediterranean Basin, while the crop is also grown successfully in mountainous areas of Europe, Asia, India and the American continent.

But although barley is cultivated under some of the most extreme conditions of temperate grain crop cultivation, its most important areas are on the more fertile plains of the north temperate regions, where it is coincident with, or overlaps, the other temperate cereals, particularly wheat. The U.S.S.R., China and the U.S.A. have the greatest national acreages, but the continent of Europe as a whole is the greatest centre of production and includes areas where the heaviest yields per

VARIETIES OF BARLEY. Left *Spratt-archer. A two-row hybrid of first-class malting standard. The ear is of the ' lax ' type.* Centre *Pioneer. A two-row malting barley of ' lax ' type, bred for winter harvest.* Right *Prefect. Six-row malting barley. A hybrid from a six-row and two-row cross*

acre are obtained. China is probably the greatest single producer of barley, but the average estimated yields per acre of the Chinese farmer, like those of the American and Russian farmers, do not compare with that obtained in Belgium, Denmark, Holland and the United Kingdom where the yields are among the highest in the world.

Economic and agricultural significance

The position of barley as a cereal crop has changed materially since it ceased to have any material importance as a human food except in certain isolated areas in northern Europe and Asia and in mountainous Tibet, where it survives under extreme conditions where the winters are too severe and the growing seasons too short for other grain crops. The world barley crop is now essentially a livestock feed, and must be evaluated primarily for its contribution to livestock husbandry, which is the principal reason for its continued and expanded cultivation, particularly in areas where the growing conditions are suitable to the production of a comparatively high protein content in the grain. As a crop providing livestock feed, barley occupies a place of varying significance and importance in different agricultural systems, but it is in terms of this form of utilisation that the crop must be considered as a contributor to world food supplies.

In many of the more intensive barley-growing areas, however, the crop has a valuable financial outlet for malting. This market is so important in some countries that, although only a proportion of the crop can be absorbed in this way, the main interest of the grower is to provide a good malting sample because of its higher market value. Although the market for malting barley makes considerable demands on the crop in certain countries, its total effect on the world crop is small, as also are the even smaller demands such as for distilling and pearling. Nevertheless, the stability and continued cultivation of the barley crop is very much dependent on these demands in certain localised areas, and must be considered as significant in the contributions of the crop even if only from the aspect of by-products for livestock feed.

World production and productivity

During the period 1935-39, which may be taken as the last ' normal ' five-year period, the estimated world average acreage of barley was 114,150,000 and the average total yield 2,338,000,000 bushels, thus giving a yield per acre of approximately 20 bushels. Although the figures for the post-war period indicate a drop in the total acreage in some years, there is no evidence that there has been any material change in the average yield per acre. There is little doubt that the yields in some countries showed a decline after the war because of shortage of fertilisers and other difficulties, while in other areas there has been a slight yield increase due partly to improved varieties being made available. The major fluctuations in total world production, however, depend to a large extent on the effect of growing conditions, particularly weather, on the yield per acre in the large barley-growing areas.

The most important limiting factor to increased world production is, therefore, the inherently low yields of such countries as the U.S.S.R., China and the U.S.A., where the yields are approximately that of of the world average. Though the yields vary between these three countries, which contribute between them such a high proportion, both in acreage and total grain, of the world barley crop, they are never high compared with the best standards. Denmark and Holland, for example, have yields approximately three times that of the major producers and the world average, while other good barley-growing countries, such as those of north-western Europe, Japan and New Zealand, have national yields more than twice the world level of production. All these countries with high yields, however, have comparatively small acreages, while there are many countries whose yields are not more than half the world average.

Increasing production

The dominant limiting factors to world barley production, as with the other cereal crops, are climate, soil fertility and level of farming. Total production can be raised by increasing acreages or improving yields, and the recent history of barley cultivation in the world suggests that unless there are great incentives, there is not likely to be any marked increase in the world acreage under the barley crop. It is true that there are examples in recent times of an economic incentive resulting in relatively large increases in acreages, as in the United Kingdom over the last 10 years. The United Kingdom is, however, a special case and unless there are major economic changes and national plans for expansion of barley cultivation for the production of livestock feed, the world acreage will probably be stabilised at approximately its 1935-39 level. It remains to be seen, however, how far various national schemes for bringing more land into cultivation in some of the more ' backward ' areas will bear fruit.

Increased production in the last few decades has been due to improved yields in areas with more advanced techniques.

VARIETIES OF BARLEY. Left *Prefect. A six-row winter hardy malting barley.* Centre *Campton. A two-row spring barley for feeding purposes.* Right *Pioneer. A two-row winter malting barley*

Outside these areas there have been few signs of improvement, and it does not seem probable that any further improvement can be anticipated until the agriculture in these areas shows technical advances through the greater availability of equipment, machinery and fertilisers, and in some cases also of high quality seed of selected varieties. There is no doubt that considerable improvements in yield could result from better crop husbandry in these more backward areas, but there would still remain intractable areas where climate is the limiting factor. There are, however, examples of such areas where increased production in agriculture generally is being planned by the introduction of irrigation schemes, and barley cultivation would undoubtedly benefit by such methods.

Improved varieties

In the more advanced areas of higher agricultural production, increased yields have resulted largely from the introduction of improved varieties during the last few decades. These new varieties, in both feeding and malting barleys, have been characterised by higher yields under the existing conditions, by the capacity to give higher yields under conditions of greater fertility, and in some cases by greater disease resistance. Considerable advances have been made in improving the straw characters, not only in greater strength, but also by breeding varieties with shorter straw which stands better on more fertile soils and does not suffer so much damage in high winds or in wet growing seasons. These shorter straw forms are also for the most part better suited to combine harvesting, a development in the mechanisation of barley growing which has made the farmer less dependent on weather conditions, thereby making it possible to handle larger acreages and reduce losses under bad harvest conditions.

Higher technical efficiency

Production could be increased even in the areas of higher technical efficiency by the better use of the improved varieties already available, and there are undoubtedly conditions where the high-yielding varieties are not being fully exploited. Further increases in production will depend on the introduction of still better varieties with higher yields and greater disease resistance, but this will be ineffective unless the economic conditions justify the higher levels of farming which such improved varieties would demand.

But the major problem in increasing world production is to remove the limiting factors imposed by growing conditions and by low standards of agriculture and husbandry in some of the extensive areas of barley cultivation.

Limited water supplies can be met in some instances by irrigation, low fertility by better methods of farming, and disease by improved crop husbandry, by chemical control and by resistant varieties.

Aim of improvements

All methods must be used to reduce the hazards responsible not only for the consistently low yields over large areas, but also for the great fluctuations in yield which often result in extremely low production over large areas. The problem is, therefore, not only to raise yields, but also to eliminate the lean years in the areas which are subject to the greatest hazards.

GALL MIDGES AND CROPS

The absolute necessity in entomology, as, indeed, in the other branches of science, of restricting investigations within narrow limits, if a sound knowledge of the systematics and bionomics of insects is to be gained, is generally recognised. In this volume* on gall midges associated with crops of economic importance, the sixth of the series dealing with these insects, the valuable results of specialisation are manifest and should provide yet another incentive to those whose interests are perhaps too wide to take up the specialised study of one or another of the less-known groups of insects. The choice is unlimited, for, although the advance of entomological science is rapid, our present knowledge, for the most part in the sphere of bionomics, of most groups is still very meagre.

To the results of his own extensive and thorough investigations the author has added the information collected by other workers in many parts of the world regarding the *Cecidomyidae* and their economic importance. This additional information greatly enhances the value of the author's labours.

The volume is not as fully supplied with figures as one might wish, but the comprehensive keys make up, to some extent, for this deficiency.

An appendix on chemotropic studies by H. C. F. Newton and an extensive bibliography complete a work that will be of great value to economic entomologists.

N. C. E. MILLER.

**Gall Midges of Economic Importance*, Miscellaneous Crops, Vol. VI. By N. F. Barnes, M.A., Ph.D. Crosby Lockwood & Son Ltd., London, 1949, pp. 229, 15s.

Agricultural Education

The IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

THE Annual Report of the Imperial College of Tropical Agriculture for the year 1948, recently published, provides interesting information concerning this important institution. Located at St. Augustine's in Trinidad, eight miles from the capital of that island—Port of Spain—and founded in 1921 as the West Indian Agricultural College, it now has 28 years of continuous and successful operation to its credit.

Its main objects are to provide instruction and to carry out research in tropical agriculture. It offers a diploma course of instruction of three years' duration intended for students with a good general education intending to follow agriculture as a profession and post-graduate advanced courses leading to the Associateship of the College. It is the recognised centre for post-graduate training in tropical agriculture for the agricultural service of the Colonial Empire.

For many years the College has been forced to work with funds which were barely sufficient to enable it to fulfil its functions, but during the past three years it has been possible to place the finances on a more satisfactory basis and to effect reorganisations and extensions which have enabled it to become in fact, if not in name, the central agricultural research institution for the whole of the British Caribbean region.

Considerable additions to the buildings and equipment have already been made and others are in process of completion, while progress has been made with the recruitment of badly needed senior technical staff.

An integral part of the College activities are four major research projects dealing respectively with bananas, cocoa, sugar and soils, the cost of which has been provided under the Colonial Development and Welfare Act. The total financial provision is $4,000,000, of which $1,000,000 is accounted for by capital expenditure on buildings and equipment, the remainder being for recurrent expenditure over a period of years. When fully staffed these schemes will involve the appointment of 27 additional scientific workers to the staff of the institution.

Briefly, the objects of these four schemes are as follows :

Banana research—This scheme is intended to check the spread of Panama disease, which has had so harmful an effect on the West Indian banana industry, either by breeding varieties of banana which are resistant to it or by discovering some means of controlling the disease itself. Work on the second aspect is at present in abeyance pending the appointment of a plant pathologist, but breeding work, which had already been in progress for some years, is being actively pursued, the first stage being the collection of material which carries the genetical factor of resistance to the disease and which can be used as male parents in producing hybrids combining resistance to the disease with desirable commercial characters. It would be rash to prophesy how long this will take, but results so far achieved appear to justify a measure of cautious optimism.

Cocoa research—This scheme aims primarily at the rehabilitation of the West Indian cocoa industry, which has declined badly owing to soil deterioration, the attacks of disease, low-yielding varieties and unsuitable preparation. The programme includes work on soil fertility, the physiology of the cocoa tree, breeding improved varieties and the study and control of the various diseases which attack the crop. A cocoa estate of some 223 acres has been acquired for experimental purposes.

Sugar research—The objects here are twofold: (*a*) To improve factory technique by technological investigation, and (*b*) fundamental research to investigate the original constituents of cane juice and to ascertain how far the by-products of the cane sugar industry can be developed for commercial use.

Soil research—The broad aim of the scheme is to improve knowledge of the characters of the soils of the Caribbean region and, in particular, to carry out a detailed soil survey of the British Caribbean colonies, a matter which is of fundamental importance to agricultural development.

Apart from these special activities, research is in progress in all the specialist departments into which the College is organised, including chemistry, botany, entomology, mycology, agriculture, animal husbandry and economics.

On the teaching side the total number of students in residence at the College during the year was 66, of which 36 were taking the diploma course and the remainder post-graduate or special courses.

A feature of the year was the introduction into the courses of lectures on agricultural extension methods, rendered possible by the appointment of a lecturer on this subject (Mr. C. W. Lynn, whose report to the Colonial Office on agricultural extension practices in various countries was reviewed in the September 1949 issue of this journal). As many of the students will in due course be concerned with the dissemination of knowledge on new agricultural methods, this innovation is likely to be highly important.

The development of the newly established University College of the West Indies has led to considerable discussion about the relationship between it and the Imperial College in the matter of agricultural teaching. It is recognised that a degree course in agriculture must be provided in connection with the University College eventually, but agreement has not yet been reached on the precise form which it should take, nor as to the part in it which the two institutions should play. It is hoped, however, that full co-operation between the two institutions will eventually be attained.

With the establishment also of University Colleges in the Gold Coast, Nigeria and Uganda, all of which will have faculties of agriculture, it has become highly desirable that their teaching curricula should be closely co-ordinated with that of the College and official discussions to this end are contemplated.

[Photo: Pakistan Government

Primitive ploughing in the North West Frontier Province, Pakistan

Needed—A Revolution in Tropical Peasant Farming

G. B. MASEFIELD

Department of Agriculture, Oxford University

The tropical regions can make the largest single contribution to increased supplies of food and raw materials. Production, however, mainly depends on the native inhabitants, whose traditional methods give small returns for great expenditure of effort. If the potentialities are to be realised native agricultural methods must be modified to meet the new conditions. In fact, an agricultural revolution is needed. The problem is difficult and complex, but its solution is urgently required.

In the following article some of the basic considerations underlying the question are discussed by the author, who was, until recently, engaged in agricultural extension work among native cultivators in the Uganda Protectorate.

ONLY since the beginning of the present century has the sustained attention of scientists been given to the improvement of tropical peasant agriculture. It is therefore not surprising that we still lack much of the essential information on which improvement must be based. In estimating the possibilities a balance must be struck between proved methods which could raise production if they were put into general practice and the problems on which advice, founded on adequate experience, cannot yet be given.

Defining of data

Data are still very deficient concerning environmental factors; elementary meteorological data, such as rainfall records, are still only available from recording stations sparsely scattered over the tropics, and the development of new areas, such as the East African groundnuts scheme, usually brings to light local variations in rainfall which are of profound importance to the practical farmer. The same applies to the distribution of soil types; so far the devoted work of a few soil surveyors has only sketched in the broadest outlines. The recent realisation that the outstanding characteristic of most tropical soils is their poverty indeed represents a great advance, but details need to be filled in everywhere. Fuller knowledge of the ecological background is equally important. The annual burning of grassland is an almost universal tradition in the tropics, which has been roundly condemned under some conditions and grudgingly accepted under others, but we still lack essential information on the effect of fire on the growth of tropical grasses and on the composition of the grassland flora.

The same ignorance extends to many aspects of agronomy and provides continual surprises even for trained agriculturists. When soya beans were introduced into cultivation in Uganda in 1942 it was expected that this leguminous crop (even though it was not inoculated) could play a useful part in maintaining soil fertility; and it was with surprise that a

shoal of complaints were received from cultivators about the bad effect of soya beans on the succeeding crop. Yet this is in accordance with recent American conclusions that this crop, even when well nodulated, considerably exhausts the soil.[1] Very little is known of the relative effects of the other numerous tropical pulses on fertility, or of their exact role when grown with cereals in the very common native practice of mixed cropping.

Data are equally scarce about tropical pasture grasses, and particularly their nutritive value. There is some evidence[2] to support the suggestion that the hot, drying winds of tropical dry seasons perform a natural grass-drying operation upon certain grasses, conserving their protein content at a valuable level as they stand; but too few analyses have been done to enable a general check on such an important point. Investigational work on such subjects as plant breeding and disease resistance has been largely confined to a few tropical crops of prime commercial importance, and in the case of food crops, such as the millets and root crops, our knowledge is rudimentary.

Africa. A peasant woman grinding corn in Uganda

Value of surveys

Valuable information of two kinds concerning existing agricultural practice can be obtained from farm and village surveys. One is purely agronomic and concerns such points as the acreage of each crop grown per cultivator, the usual planting date, the incidence of pests and diseases, and the yield per acre. The other is economic and concerned with labour demands, cost of production, and income derived from each crop. A few very useful surveys of this kind have been conducted in some tropical countries; but they are required on a far greater scale. A study of variations in existing farm practice is an essential preliminary to any plans for its improvement. It is also true that the efficiency of farm management cannot be correctly assessed, nor comparisons made between different farming systems, unless some of the farmers keep accounts in at least a rudimentary form. This prospect is still a long way off for most tropical peasants, but some governments have realised the importance of encouraging book-keeping as farmers become sufficiently educated.[3]

In some territories efforts have been made to determine the ideal size of a small-holding and the rate of stocking it needed to support a peasant family. Some have not produced useful results through failure to distinguish between two separate problems. Evidence is usually sought on (*a*) the amount of produce which the farmer can obtain from a unit area of land or number of stock, and (*b*) the area of land and number of stock he can manage with his family labour or such other help as he can command. Unfortunately each of these figures depends on the other; for example, a man with more land than he can manage gets low yields of crops, and it is accordingly impossible to measure both figures in the same experiment; one must be held constant while the other is determined for that particular level. Such investigations are, indeed, essential to sound agricultural planning, but they are extremely complex to carry out.

Effect of environment

It must be borne in mind that under poor environmental conditions, improved strains of crops and livestock may not be able to fulfil their genetic potential. Peasant farmers may find that a dairy cow of superior strain yields no more milk than does the local scrub breed, if it is only fed on the same rations as the latter. Failure to give it sufficient food for its productive power may be due simply to ignorance, or to the fact that the current farming system does not provide enough feed to meet the extra demands. Both these effects must therefore be taken into account when the superior animal is introduced.

Similar cases arise with crops; hybrid maize, which is capable of giving very high yields, may show little improvement over local strains if it is planted on worn-out land or without manuring. The provision of such first or second cross types of seed also raises another difficulty in primitive countries; for its production demands a considerable commercial organisation and will often be impossible to arrange in a country where no seedsmen exist and where the initial demand would be only for very small quantities.

Psychological and physical factors

There are other factors which form a background to planning for agricultural improvement. One is the psychology of the farming community. Most natives of the tropics set a much higher value on leisure than do Europeans, and hence the extra produce to be obtained from an extra hour of work must be distinctly higher, to provide an incentive to this work, than with the European. Again, many peasant cultivators have become habituated to slack seasons between crops; and however much the introduction of mixed farming may be shown to benefit them will be reluctant to keep animals because of the regular work involved all the year round.

Moreover, many natives of the tropics are incapable of exerting the same physical strength as a European in his own country.[4] This has agricultural implications. If some men are less strong than others, implements must be made to fit their strength or they will not be able to give of their best. Some of the two-wheeled horticultural tractors tax the strength of a British worker to drive all day especially on small plots with frequent turns, and hence they are far from suitable for the tropical peasant.

Finally, educational standards are inseparably connected with agricultural im-

provement. A man cannot calculate the appropriate quantity of manure to put on a plot of a fraction of an acre if he knows no arithmetic; nor can he mix an insecticide unless he can read the ' instructions on the tin.' Without education he cannot improve his knowledge by reading agricultural pamphlets or journals. Women, who do the bulk of the agricultural work in many tropical countries, are even more illiterate than men.

Land tenure

A factor of another kind which can limit agricultural improvement is the land tenure system. Lord[5], writing of the improvement of rice yields in Ceylon by weeding, says ' If the cultivator received for his own use all the increase, weeding is profitable and may be very profitable but where half the increase goes to the landlord, the economic incentive for improvement may be insufficient.' The mechanisation of agriculture may be rendered almost impossible by the fragmentation of holdings into tiny patches, as has been found in Cyprus and elsewhere.

Communications

Sometimes the factors which make agricultural improvement impracticable are beyond the control of agriculture itself. One of the most frequent is poorness of communications. In 1944 a record Uganda maize crop, grown for export to Kenya, proved beyond the capacity of the railway to carry, and much of the surplus was perforce left to rot. On a much bigger scale, groundnuts for export accumulated in Northern Nigeria until in 1948 there were 330,000 tons, or more than a whole year's crop, in stock because the transport system could not move them to the coast. Of what use is the improvement of crop yields by technical skill when the resultant produce is unable to reach its market ?

Another such limiting factor is water supplies. In Africa there are areas of empty land where the rainfall is sufficient for crop growth but settlement cannot be made because there is no permanent source of drinking water for man and beast.

Industrialisation

Industrialisation, too, may be of the greatest importance to agriculture. There is little hope that in our time local factories will supply the tropical farmer with tractors, agricultural implements, and spare parts as readily and as cheaply as the European or American farmer gets them. But each new factory opened in the tropics to make hoes, sacks, or other agricultural essentials means that these can be obtained sooner and with more certainty, even if not always more cheaply. The use of artificial fertilisers in the tropics has been severely limited by their high price, but new possibilities, which may revolutionise local agriculture, will be opened up by hydro-electric schemes for Rhodesia and Uganda, which can provide power for the local manufacture of sulphate of ammonia and the discovery of large phosphate deposits in East Africa is also full of significance for the future.

Africa. Madi peasants hoeing near the Uganda-Sudan border

Experimentation

Against a background in which so many factors play their part, experimentation must often be carried out on a village scale, for not all questions can be answered by simple investigations on an experimental farm. This is particularly the case where both technical and economic factors are interlocked, as in the problem of mechanisation. For example, the acreage of peasant crops which will economically support a given implement, and which such an implement is capable of serving efficiently, can only be finally determined by village trials, although the initial data on which such trials are designed will generally be gathered on an experimental farm.

Group farming

In peasant agriculture it will rarely be economic for a single farmer, even if he has the necessary capital or it can be made available to him, to pay for cultivating machinery, modern methods of pest control, or the grading of his produce. Agricultural improvement therefore demands provision of group services. These may take different forms. Co-operative societies have achieved considerable local success. Implements may be provided by contractors, who hire them out to the peasant. In recent small-scale trials in Uganda, the Government has itself been the contractor and hired cultivating machinery to peasants. Special schemes may be designed to suit local conditions. In the Gezira area of the Anglo-Egyptian Sudan the triple partnership between the Government, the cultivators, and the Sudan Plantations Syndicate has achieved conspicuous success with the cultivation of irrigated cotton and other crops. The East African groundnuts scheme represents another approach to the problem, which takes us beyond the bounds of peasant farming, though its ultimate ideal is the ' distant goal of transferring the control of the undertaking to the people themselves, possibly on some co-operative basis '.[6]

A different form of group farming was envisaged by the West African Oilseeds Mission, who projected ' tractor units ' of 600 acres, each of which would be worked by 20 families having user rights to 20 acres each out of the 400 to be cropped annually, with each farmer contributing to the costs of mechanical tillage out of the proceeds of his crop sales.[7] Another interesting scheme is the settlements under ' corridor cultivation ' in the Belgian Congo, where the peasants work contiguous strips on which the same succession of crops is cultivated, making group services very easy to provide.[8]

Size of units

While grouping of farms may be desirable, or even essential, it has to be remembered that, once the minimum size of unit has been passed at which it is economic to operate modern machinery whether for cultivation or processing of crops, great size does not in itself necessarily confer agricultural advantage. Too large an organisation may even introduce dangers of its own such as a top-heavy supervisory staff or a lack of technical control over outlying sectors.

Extension methods

The possibility of getting improved methods put into practice by peasants depends to a great extent on the extension methods used. In this field a great deal of research remains to be accomplished. No detailed comparison has, for instance, been made between the relative efficiency of 'demonstrators,' who have achieved such striking results among African farmers in Southern Rhodesia[9], and 'instructors,' who are the normal extension agents in most other British colonies. Modern techniques of publicity such as the Press, pamphlets, broadcasting, posters, films, film strips and other visual aids are only just beginning to be critically studied from this angle in tropical regions[10]. Not only must the relative number of improvements effected through each medium be investigated, but also the relative cost of attaining a desired improvement by each medium. In this respect, research in tropical territories lags far behind the attention which has been given to the subject in the United States[11].

Prospects for improvement

What then, in brief, are the prospects of improving peasant agriculture against such a background? It is clear that the most important objective must be not the introduction of any single technical method, for different conditions will demand many different methods, so much as a revolution in the peasant's conception of farming which will make him receptive to improved methods. This can be clearly illustrated by reference to the problem of the maintenance of soil fertility.

Over most of the tropics, the traditional farming system is one of shifting cultivation, by which a sparse population maintained itself in ecological balance with its environment, while the cultivated land was able to regain its fertility under long periods of natural regeneration of the vegetation. With the rapid increase in human and livestock populations in modern times, the system has broken down. Attempts at maintaining soil fertility by the use of manures or green manuring have proved in many tropical areas to be only palliatives, incapable of arresting the slow decline in fertility of continuously cultivated land.

The work of Dr. W. S. Martin in Uganda [12], which showed that by deliberate planting of suitable grasses as a restorative crop the period of regeneration could be greatly shortened, marks a new era in the scientific approach to these problems. but does not provide a universal solution. While it appears admirably suited to areas of well-distributed rainfall and heavy soils, it is by no means certain that it would confer the same benefits in, say, the Rhodesias where owing to lack of rain grass makes practically no growth for half the year. On the light soils of Southern Rhodesia, there is evidence that the application of farmyard manure is a more effective method and will, in fact, maintain fertility over a long period of continuous cropping[13].

What is wanted, therefore, is that the peasant should become aware of the necessity for following advice on cultivation matters based on suitable local experiments. This is equally important also in relation to soil conservation measures which are indispensable in tropical and sub-tropical countries, but whose details demand an infinite local variation.

A similar change of heart is needed to make the peasant view grass as an important crop. Whether for grazing, fodder, soil regeneration, or the prevention of erosion, grass must receive the same degree of attention as is given to other main crops. It is, however, not surprising that the primitive African peasant has not yet reached this stage, since even the British farmer is only just beginning to take this view of grass, which is the most important crop of his country.

Inevitably, with the increasing development of the tropics, the peasant must make the change from extensive to intensive farming. Extension of the acreage cultivated by reclamation, irrigation, drainage, and the provision of water supplies is still possible over wide areas, but increase in yields per acre is the central problem which will become ever more urgent with increasing population. Apart from ranching practice in under-populated regions, intensive farming for a high output per acre is the secret of increased farm incomes and a rising standard of life in all agricultural countries. This change of outlook is an essential pre-requisite for the adoption of manuring, efficient methods of pest control, and more scientific methods of cultivation. It is also necessary if crop-farming peasants are to be induced to introduce livestock and thereby adopt mixed farming, with its output of higher-priced animal products, improvement in the farmers' diet, and the opportunity which it gives to increase fertility by grazing the cattle on leys and the making of farmyard manure.

Finally, there can only be limited progress until the primitive hoe is in large part replaced by implements which give a greater return for the same amount of labour. But though the hoe may be considered a dying implement, it will not be dead for a long time yet; and in regions of high fertility where cultivation is horticultural rather than agricultural it may show a surprising economic vitality. There is even a danger that, in our enthusiasm to introduce heavy agricultural machinery, we may overlook the improvements, of which the manual tools and their methods of operation are no doubt susceptible. Technical skill and ingenuity must, in fact, be applied, not only to one pattern of development, but at all stages of the evolutionary process.

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U.S. Agricultural Experts Finish African Survey

THE three American agricultural experts who have just completed a 2½-month survey of British territories in Africa for the Marshall Plan and the Colonial Office, state that intensified research would aid in developing production there.

The experts, who have returned to the United States, are Dr. W. V. Lambert, Dean of the College of Agriculture, University of Nebraska; Dr. M. A. McCall, Assistant Chief of the U.S. Department of Agriculture's Bureau of Plant Industry, Soils and Agricultural Engineering; and Dr. Marlin C. Cline, Professor of Soil Science at Cornell University. In West Africa they were accompanied by Mr. G. W. Nye, O.B.E., Deputy Agricultural Advisor to the Colonial Office.

They reported to the Colonial Office in London on their way back to the U.S. and also to the Economic Co-operation Administration (Marshall Aid) Mission to the United Kingdom.

Their survey, which was reported in the September issue of WORLD CROPS, was part of the E.C.A.'s Technical Assistance Programme. It was requested by the British Government and covered, east, central and west Africa. Its aim was to determine what E.C.A. could do to help in the development of agricultural research in all of its phases, with the aim of increasing agricultural productivity.

'The problems we encountered were numerous,' said Dr. Lambert, leader of the mission, 'so numerous that we realised that we could not possibly suggest solutions for all of them. Nor, indeed, was that our job. We are technicians. What we do hope is that the measures we are suggesting to the Colonial Office will assist the African territories to push forward their agricultural production programme, so that they, in turn, can help the United Kingdom, the Commonwealth, other European countries which have overseas dependencies and the rest of the world, including the United States.'

In this connection, he added, research will play a dominant role. 'It has been proved that research pays dividends over and over again in hard cash. There are blind alleys, of course, but research specialists can save years of wasted effort. It is the best investment any nation can make.'

The experts, who travelled more than 21,000 miles by aeroplane, car and rail in their trip through eight African territories, praised the awareness on the part of the administrators and experts on the scene of the problems to be overcome.

'The British and colonial authorities have gone about their task vigorously and, considering the fact that they are very short-handed, have made remarkable progress,' Dr. Lambert said.

He added that the mission had been impressed by the enormous potentiality for plant growth, which is characteristic of much of the tropics. With sufficient water, vegetation flourishes and abandoned land rapidly returns to bush. Geologically Africa is an old continent and most of its soils are deficient in basic minerals essential to plant growth, he pointed out. It has been possible to supply this need by letting land grow back to bush for several years because deep rooted plants draw up from the earth the necessary minerals.

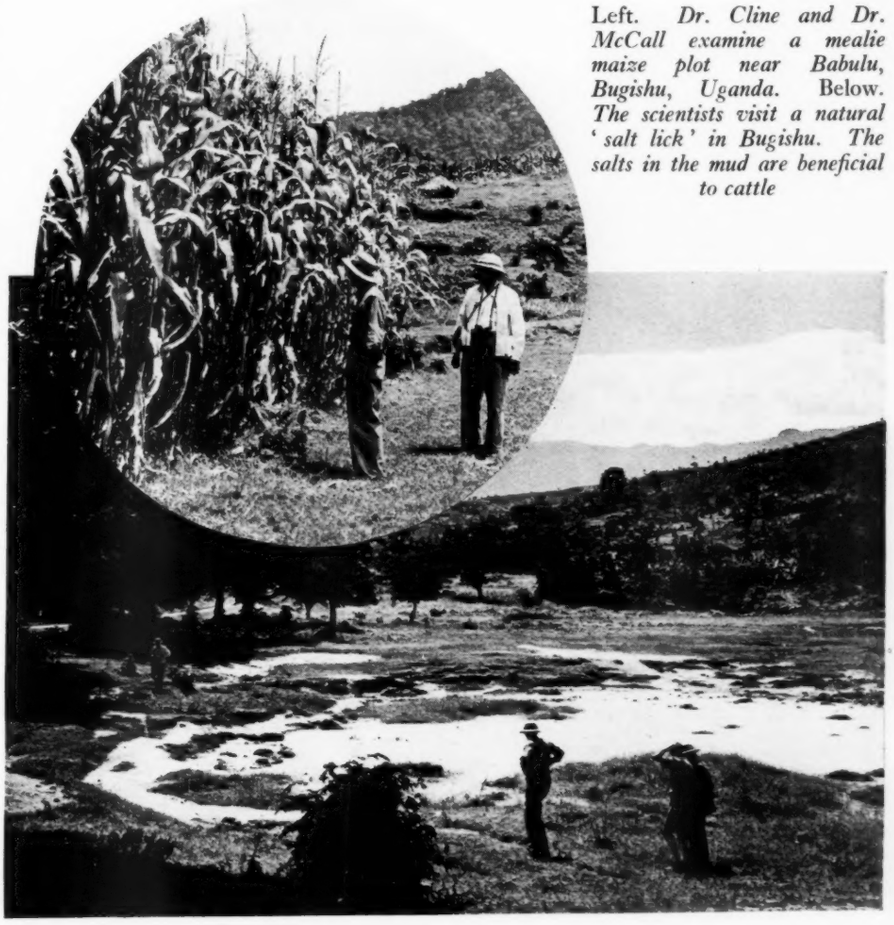
'One of the encouraging things we observed is the great extent to which soil conservation practices are being employed in many areas,' he said.

'These must be supplemented, however, by other good land management practices if the farms are to continue to produce enough food to support the growing population.'

Cattle represents tangible wealth in many areas, and this has caused some overgrazing, he said. European livestock, however, do not thrive except in the Kenya highlands and much could be done to improve the native African breeds. This is desirable because native African cattle are more resistant to the diseases and parasites encountered there.

The trio visited Kenya, Uganda, Tanganyika, Nyasaland, northern and southern Rhodesia, Nigeria and the Gold Coast.

They were the second mission to go to Africa under the E.C.A. Technical Assistance Programme. The first consisted of two American public health experts who studied malaria, sleeping sickness and other public health conditions. In addition, another mission is surveying some of the mineral resources of the British territories, and a team of American and British engineers making a preliminary survey for a railway link between Rhodesia and East Africa is now also in Africa.



Left. *Dr. Cline and Dr. McCall examine a mealie maize plot near Babulu, Bugishu, Uganda.* Below. *The scientists visit a natural 'salt lick' in Bugishu. The salts in the mud are beneficial to cattle*

Coffee pickers in Kenya

COFFEE . . . An Export Staple of East Africa

S. M. GILBERT, O.B.E., B.Sc.

Formerly Director of the Coffee Research Station, Lyamungu, Tanganyika

After cotton and sisal, coffee is the most important export product of East Africa. Two kinds are grown, arabian coffee introduced from Abyssinia and robusta coffee which is indigenous to the region. The crop is grown both by plantations and also on African smallholdings. Research has done much to show how cultivation can be improved. In this article the author discusses the present position of the industry and its future with special reference to conditions in Tanganyika.

ARABIAN coffee has been grown in East Africa for more than half a century, having been introduced from Abyssinia, where it is indigenous, by a Roman Catholic mission. Robusta coffee is indigenous to Uganda.

The former supplies the ' mild ' coffees of commerce and the latter the ' hard ' coffees. Arabian (arabica) coffee commands a higher price than robusta.

The present total output for East Africa is approximately 70,000 tons, of which about 20,000 tons are arabica. Of this total, practically all the robusta coffee is grown by Africans in Uganda and the adjacent Bukoba District of Tanganyika. Arabica coffee is grown mainly by non-natives although, under careful and cautious fostering by governments, the proportion grown by Africans is steadily increasing in Kenya and Tanganyika.

Organisation of research

Valuable investigations on arabica coffee were carried out in the years before the war under the leadership of Gillett at the Scott Agricultural Laboratories near Nairobi in Kenya, but until the establishment of a well-equipped research station at Lyanumgu in Tanganyika in 1934, with assistance from Colonial Development Funds, the research needs of the Tanganyika industry were not fully met. More recently Kenya has developed its own research station at Jacaranda Estate near Ruiru.

Preliminary work on robusta coffee was carried out for some years by Thomas in Uganda and in 1938 a well-equipped research station was established at Kawanda near Kampala at which robusta coffee is one of the crops studied. A small station has also been opened for work on robusta coffee in Bukoba.

The above stations deal mainly with *ad hoc* research. Long range fundamental research from which coffee will benefit now comes under the auspices of the East African Agricultural Research Organisation with its main centre at Mugiya near Nairobi. All this research is well co-ordinated and there is close contact between the workers concerned.

Plant improvement

For a number of years the improvement of the coffee plant by breeding and selection has been under investigation and appreciable advances have been made. It

has been established that plants can be found which are superior to ordinary types in respect of both yield and quality, and it has also been found that these characters are inheritable and are connected with genetic factors.

In Uganda seed selection in robusta coffee has for a number of years been practised by the Department of Agriculture and improved types have been established, planting material of which is regularly distributed as seedlings from the departmental nurseries. Definite advances have also been obtained through the selection of seed in the case of arabian coffee; in certain circumstances this species is self-fertilised and there are indications that at any rate some desirable types reproduce themselves true to type from seed.

The production of new types by hybridisation is a long-term undertaking; it seems quite possible that the evolution and fixing of an improved type by this process might take many years; in consequence it has not yet been embarked upon by the African stations, although it is possible that it may ultimately be undertaken as a long-term project.

A problem that has naturally presented itself is the best manner of multiplying desirable material isolated as the result of selection. The Kenya workers have concentrated upon the propagation of selected strains by grafting upon seedling stocks. Little is known, however, of the effect of the stock on the scion and hence upon the selected clones.

In Tanganyika, on the other hand, attention has been concentrated upon propagation by cuttings from selected trees and considerable success has been achieved by this method. Actually there are about 50 acres of clonal coffee, propagated from cuttings, in bearing at the Lyamungu station. A drawback that has not yet been overcome, however, is that there is considerable mortality during the hardening-off process and, for the method to become capable of wide commercial application, this must be overcome.

In the meantime it is probable that propagation by seed from isolated blocks of clonal material provides the best immediate solution. Experimental trials have shown that clonal material established in this way gives improved yields, while the plants show much greater uniformity of type, and this, too, affects the uniformity of the resulting crops.

In this connection it is interesting to record that the Moshi Native Coffee Board have now established clonal seedling nurseries, the ultimate aim being to replace all African-grown coffee in the Kilimanjaro region with clonal material.

Cultural improvements

Mulching.—Perhaps the most outstanding success has been obtained by the application of mulches of vegetable material to both arabica and robusta coffee. The best material has been found to be banana trash, followed by elephant grass (*Pennisetum pripureum*), guinea grass (*Panicum maximum*) and thatching grass (*Hyparrhenia spp.*). Bananas are the staple food of the African growers in the coffee-growing areas, and the point is under study whether bananas can be satisfactorily interplanted in coffee without disadvantage to either crop, since if this is practicable it will materially reduce the cost of mulching. When mulching material has to be carried into the plantation from outside it increases the cost by at least 25%.

The beneficial effect of mulching can be attributed to (*a*) conserving soil moisture, (*b*) keeping the soil cooler, (*c*) increasing the nitrate content of the surface soil, (*d*) protecting the soil from erosion, (*e*) reducing weed growth, and (*f*) increasing the soil organic matter.

Pruning.—Outstanding improvement has also been achieved by the adoption of multiple-stem pruning in replacement of the single-stem pruning formerly widely practised. Briefly, this consists in pruning the trees so that there are three bearing stems instead of one. This leads to the crop being borne on the primary instead of on the secondary branches, as is the case with single-stem pruning. As the lower primaries cease to bear they are cut away until a point is reached, usually about the sixth year, when three new suckers are brought away from the lower parts of the parent stem and a new cycle is established.

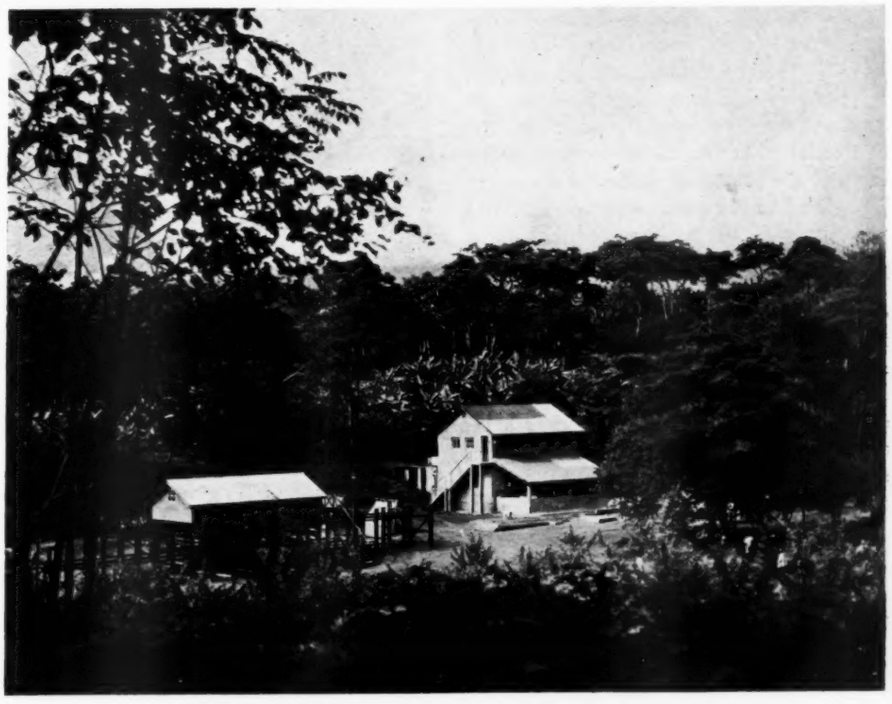
The results of experiments over nine years show that an increase of 75% in crop yield is obtained by the substitution of multiple-stem pruning for single-stem pruning, and that the pruning routine is less expensive and can be done by less intelligent labour.

Irrigation.—Irrigation in conjunction with mulching has also been found to be beneficial in Tanganyika and, with applications of about 2 in. per month to supplement the rainfall, the mulch cover can be substantially reduced with accompanying increase in yield.

Manuring.—While manuring with organic materials appears to be beneficial, little success has so far followed applications of inorganic fertilisers, at least on young coffee. However, there are indications that both nitrogenous fertilisers and phosphorus are needed in certain parts of Kenya and in the Southern Highlands of Tanganyika. Considerably more work is required to elucidate the requirements of the crop in this respect.

Cultivation

Little progress has so far been made in regard to methods of tillage and cultivation. No improvements have followed trials with



A coffee factory and drying shed, near Moshi, Tanganyika

different methods of hand cultivation; introduced hand implements such as the West Indian hoe and the forked hoe have shown no advantages over local ones, while opening up the soil by envelope forking has also not proved beneficial. Indeed, over a period of nine years the average yields from plots which received no tillage have been as good as from those which were cultivated. In a really good coffee soil a large part of the feeding roots are to be found in or near the surface layers of the soil and the difficulty is to find a method of tillage which, while controlling weed growth will not damage the surface rooting system. This problem is becoming more acute as labour shortages compel the grower to adopt mechanical methods of cultivation.

In regard to the latter, the most promising form of mechanical cultivators which have so far appeared is the rotatory hoe, of which the small orchard types seem likely to be best adapted to local conditions. There are some indications that firms manufacturing machines of this type are beginning to take an interest in the problem.

Shade trees

The question of providing shade in coffee plantations has not yet been solved satisfactorily. Nutman, working at Amani on coffee grown in tubs, has proved conclusively that coffee grows best under limited shade, but it is difficult to translate the results of his experiments to full-scale trials in the field. Meantime, growers are being advised to plant deep-rooted leguminous shade trees.

Livestock and coffee

There is an increasing tendency to associate the keeping of livestock with the cultivation of coffee, including both dairying and the raising of cattle for slaughter. This is all to the good as it enables farmyard manure to be prepared, which is essential to the maintenance of fertility. Formerly coffee growers were able to purchase at low prices much of the cattle manure they needed from neighbouring stock owners, but, with the increasing appreciation of the value of cattle manure among the peasantry, this no longer holds true and coffee growers are turning to animal husbandry on their own account to meet the need.

Methods of preparation

The traditional methods of preparing coffee from the time of picking the crop to handing over to the curing works are followed; it has been shown, however, that the key to success during these operations is cleanliness.

Curing operations are carried out in both Tanganyika and Kenya in mills owned by the industry.

Organisation of the industry

In Tanganyika a coffee-curing company in which equal shares are held by the Tanganyika Coffee Growers' Association (a co-operative body representing the non-African growers) and the Moshi Coffee Board (a statutory body representing the African growers) operates the mills. The curing company is directed by a board of six members, three of whom are nominated by each of the two constituent organisations.

In the Kilimanjaro region collections and deliveries of coffee to the mills are carried out by the Kilimanjaro Native Co-operative Union, which is a federation of co-operative societies officered by Africans.

Marketing

Of late years marketing arrangements have been highly organised, as a result largely of the controls originally established in 1939 as a war measure and since continued. In each of the three countries the Government has delegated the operation of the control to a board or an association.

As a result of these arrangements it has been possible to attain a greatly increased measure of price stability, a factor which has been of inestimable benefit, particularly during the difficult years of rehabilitation after the end of the recent war. Stable prices have been ensured for the next few years by the completion in 1946 of a contract between the local authorities and the British Ministry of Food covering the period 1947-52 and relating both to arabica and robusta coffee. For arabica coffee, prices range between a minimum of £125 and a maximum of £150 per ton.

Conversion of coffee to multiple stem

In addition to the foregoing marketing arrangements, Coffee Boards exist in Kenya and in Tanganyika for the overall control of matters relating to the coffee industries. These Boards are constituted by statutes which define their powers and functions. In Tanganyika the Board originally confined its activities to arabica coffee, but these have now been extended to include robusta.

Outlook for the industry

It is probably true to say that the immediate outlook for the native industry is more favourable than for the non-native plantation industry.

In many native areas there has been a marked tendency to introduce improvements and to combine together for this end. For example, in the Kilimanjaro area the native cultivators have accepted a number of measures of control making for greater stability; under the Moshi Native Coffee Levy Order a cess on the crop harvested is imposed, graded in amount according to the price, to furnish funds to finance improvements, and substantial amounts have already been collected. Moreover the Moshi Native Coffee Board is empowered, under the native Coffee Ordinance, to issue directions to growers concerning the cultivation and preparation of the crop. These measures must add security to the outlook and make for a stable future.

On the other hand, the non-native plantation industry is handicapped by the growing scarcity of labour and ever rising labour costs, which are not accompanied by any increase in the efficiency of the labour employed. Save in the matter of the control of certain pests and diseases, the introduction of improvements is a matter which lies entirely with the individual owner, who at times is handicapped by lack of funds. It is possible that in Tanganyika the establishment of a Land Bank will assist in this direction as it has done in Kenya, but nevertheless the outlook is by no means assured. It would appear that the most promising development may lie in the investigation and application of whatever labour-saving devices may be possible, combined with the modification of the system of production to include some form of animal husbandry.

The Control of Insects Infesting Stored Foodstuffs

Part II

THE USE OF CONTACT INSECTICIDES

E. A. PARKIN

Pest Infestation Laboratory, Slough, England

An insecticidal smoke generator in operation on a fire-proof plate

The selection and methods of application of contact insecticides for controlling pests in stored foods are described in this article. The first part of the article, published last month, dealt with the significance of insect infestation of stored foods, and considered the general problems of control as well as the properties of the contact insecticides commonly used in warehouses and other stores.

SOLUTIONS of 0.65 or 1.3% wt./vol. pyrethrins in a heavy, refined, mineral oil are in common use in Great Britain for the control of many types of insect infestation in stored produce. The carrier oil, a refined, medium-heavy petroleum oil somewhat less viscous than medicinal liquid paraffin, is chosen chiefly to satisfy the stringent regulations governing fire risk in this country, but also because it will not taint sprayed goods. This type of spray was, in fact, developed in England about 1935, particularly for the control of the Cacao moth, *Ephestia elutella*, and the Indian Meal moth, *Plodia interpunctella*, infesting boxed dried fruits in store under circumstances where fumigation was not possible. Its use has since been extended to the control of most species of insect pests of stored foodstuffs.

Pyrethrum - in - heavy - oil sprays, sometimes incorporating other insecticides or activators, may be used in three ways: as mists, direct sprays or films. Their successful application requires a suitable compressor supplying air at up to 80 p.s.i. pressure to one or more atomisers of the paint-spray or oil-spray type. It is wise to choose the design of atomiser which, whilst capable of doing the job, has the fewest possible adjustments, and to ensure that all operators receive a preliminary demonstration of the correct way to use the apparatus.

Mist spraying

Mist spraying has now been largely superseded by direct spraying and film spraying, but is still used occasionally for the control of moths with 0.65% pyrethrins. Windows and doors, etc., must be closed to exclude strong draughts, machines and spouting which may harbour moths opened, the sprayer is set to give a fine mist and the building or room is filled with it as quickly as possible. During application, some of the spray should be forced through the channels between boxes and bags of goods stored in piles. The treatment is best given at dusk, when the moths fly most actively. The spraying should be repeated daily during the emergence period of the insects, and this makes the procedure costly in labour and materials. The mists are on the borderline of aerosols

and can also be produced by machines working on the nebuliser principle, by which the coarse droplets are removed from the spray before it is released into the atmosphere. These nebuliser machines can be left running for long periods without attention, but they generate a mist very slowly and without the penetrative power of that carried on an air blast.

Direct sprays

Direct sprays and film sprays can be applied in one and the same operation, in the course of which a good deal of mist is incidentally formed. Direct sprays are used to combat accessible insects and are of importance mostly in controlling residual populations in empty stowages that have been cleared of dirt and debris. The atomiser is set to a fairly coarse adjustment and the spray of 1.3% pyrethrins (or its equivalent) directed at the insects until they are well wetted. The grain weevil, *Calandra granaria*, has been found very susceptible to spray oil alone, which may therefore be used without pyrethrins, so long as other species are not also present.

When stowages are in poor repair or goods are in store, a high proportion of the insect population will be inaccessible to a direct spray, being hidden in cracks, between boxes and bags, or within the goods themselves. By directing a coarse spray of 1.3% pyrethrins (or its equivalent) on to the walls and floor round an infested parcel of goods and, in some instances, by applying the spray to the surface of the commodity or its containers, an oily film is deposited which should act on insects subsequently wandering over it. Spraying should start on the floor and proceed up the walls to the ceiling, so that any insects which fall will alight on a treated surface. The rate of application of insecticide is usually 1 gal. (Imperial) per 2,500 sq. ft. (1 litre per 50 sq. m.) and during treatment any exposed insects will, of course, receive a direct spray.

Film sprays

Unfortunately, the most absorbent materials found in warehouses, such as brick, limewash, cement and concrete, soak up the insecticide so rapidly that, after a few hours, there is no longer sufficient left on the surface to affect many of the common species of stored product beetles. Certain materials, *e.g.* wood and sacking, will maintain a toxic film for at least several days, and relatively or completely non-absorptive materials, *e.g.* grain, glass, metal, will maintain a toxic film for several weeks if the pyrethrins are not otherwise detoxified by excessive light or heat. D.D.T. solutions in heavy oil have been found to behave similarly.

The application of an oil-spray to a lime-washed brick wall pre-treated with gelatin solution to reduce absorption

Pyrethrum-in-oil films, however, can be successfully applied to absorptive surfaces which have been pretreated with an aqueous 10% size or 5% gelatin solution in such a way as to seal the pores and prevent capillary suction effects. Such a pretreatment will serve as a foundation for several applications of insecticide.

D.D.T. and B.H.C. have been little used as sprays in heavy oil, as they can be applied more easily and usefully in other ways, but now that nearly odourless gamma-B.H.C. concentrates are available, up to 0.5% of this insecticide is sometimes incorporated in pyrethrum sprays to kill mites and the more resistant insects, when there is no risk of contaminating foodstuffs.

Aerosol bombs

Recent developments in the application of oil sprays to food stores are the aerosol bombs and thermal fog applicators.

An aerosol bomb in its most common form consists of a metal container of about 250 to 500 ml. capacity fitted with a device for opening and closing a small orifice. The container is filled with a solution of insecticide dissolved in a propellent which is a vapour at ordinary temperatures, except under the pressure generated in the closed container. During operation, the internal pressure in the container forces out of the orifice a spray of droplets, from which the propellent immediately evaporates to yield a mist of small droplet size.

Small aerosol bombs have been on the market in the U.S.A. for two or three years for household use and larger generators are being made for trial in horticulture and agriculture. The small generators are very simple and convenient for small-scale use against spoilers of foods like moths, houseflies, blowflies and cockroaches, but the generation of mists by this method is, at present, too expensive for large-scale work in warehouses, etc. It is not surprising, therefore, that scarcely any mention has been made of these aerosol bombs in publications on the control of insects in foodstuffs, but it has been reported that the mists

Grain weevils killed by B.H.C. dust on the floor of a stowage

were effective in controlling the Cheese Skipper fly, *Piophila casei*, and showed promise against the Indian Meal moth, *Plodia interpunctella*, but not against Rust Red flour beetle, *Tribolium castaneum*, or mealworm larva, *Tenebrio obscurus*.

Thermal fogs

A thermal fog applicator produces a very large volume of mist in a strong air blast by injecting an oil solution or emulsion of insecticide into the exhaust from a combustion chamber in which air and petrol vapour are compressed and exploded. Some 10 to 40 gal. per hour of insecticide can be atomised and no significant decomposition of insecticides in a heavy-oil base during the process has been reported. The generator is easily transportable and is intended primarily for treatment of growing crops, orchards, fly- and mosquito-ridden areas, etc., but the mist can be passed through one or more ducts about 4 in. in diameter into buildings such as warehouses and flour mills. Too few trials have so far been undertaken to assess the value of the fog applicator for treatment of insect infestations in food stores and factories.

WATER SPRAYS

It is generally advisable to avoid the application of water to foodstuffs and their containers, but water-based insecticides in the form of dispersible powders and emulsions can be employed for the treatment of empty stowages. D.D.T. emulsions have so far been little used because of the difficulty of finding an oil-phase solvent in which D.D.T. is readily soluble and which will not cause any risk to the operators during application. Moreover, emulsions, like oil sprays, rapidly soak into absorbent materials and are greatly reduced in effectiveness.

Water-dispersible powders

No such difficulties exist with the water-dispersible powders, which are available containing 50% D.D.T. or 6.5% gamma-B.H.C. The highest concentration of insecticide should be used to minimise the masking effect of inert diluents. They can be transported dry, need only be mixed with water just before application, involve no fire risk and can be applied with many types of garden sprayers or with lime-washing equipment.

Dispersible powders are of particular value for application to the floors, walls and ceilings of stowages, the solids being largely filtered out on the surface during treatment of absorbent building materials. They can be sprayed successfully on to any surface from which water does not run off too readily and can replace the usual lime-washing, although they rub off more easily than most lime-washes. As a general guide, a suitable dispersion of the concentrated powders (50% D.D.T. or 6.5% gamma-B.H.C.) is made by stirring 12 to 14 oz. of powder into 1 gal. of water and applying this to 2,000 sq. ft. of surface 90 g. per litre applied to 42 sq. m.); full instructions are obtainable from the manufacturers. All surfaces must, of course, have been cleaned of dust and debris before treatment is applied. These sprays act as residual toxic films and their insecticidal effect persists many weeks or months, according to local conditions.

A recent addition to the water sprays is a water-dispersible 50% D.D.T. paste which is claimed to have the advantage over powders that no inert diluent is present, but no detailed report of the performance of such a paste has yet been seen.

DUSTS

Insecticidal dusts fall into two groups, the so-called inert dusts and the chemical dusts. The former consist of finely ground minerals and certain other specially prepared dusts which have a physical action on the insect, interrupting the water-retaining layer of the cuticle, thus causing death from desiccation. The latter consist of an ordinary contact insecticide adsorbed on or diluted with a suitable non-toxic powder.

Inert dusts

The inert mineral dusts were first investigated in Germany, later in the U.S.A. and, during the 1939-45 war, particularly in Great Britain and Australia for application to grain. The effectiveness of the dusts against the grain weevil was found to be largely dependent upon the hardness of the material, the particle size and the evaporating power of the surrounding atmosphere. The harder the material the greater was the effect, but the greater also was the cost of grinding to a suitably small particle size.

Moreover, it was found in laboratory experiments at 20 to 25°C. that the dusts worked poorly at relative humidities above about 75%. Dusts such as finely ground felspar, dolomite, magnesite and anhydrite have been shown by practical tests to be effective in preventing and controlling weevil infestations, when they are mixed

with grain at the rate of 1% by weight. Their use in Great Britain has been very restricted, because the clouds of dust formed in the atmosphere during treatment and subsequent handling of grain make working conditions unpleasant. They have been used on a small scale for treatment of seed stocks on farms and for control of infestation by mites, which proved very susceptible to their effects, but they are now superseded by the chemical dusts. Inert dusts can be used with advantage in hot, dry climates where a supply of a suitable dust is available, *e.g.* in Egypt where considerable use is made of ground rock phosphate mixed with sulphur, for, once they are mixed with the grain, they continue to exert their insecticidal action until they are removed. Their removal is easily effected by the normal mill cleaning processes prior to grinding. If grain is clean when put into store, it can be protected against insect attack by surface treatment with a heavy layer of dust, but really good results are obtained only with the most effective dusts such as alumina.

Chemical dusts

The chemical dusts act in the way characteristic of the particular contact insecticide they contain, namely pyrethrins, D.D.T. or B.H.C. The use of pyrethrum dusts for protection of grain on a large scale is at present under investigation. D.D.T. and B.H.C. dusts suffer the disadvantages of their active constituents, namely somewhat high toxicity to man and animals, and, in the case of B.H.C., the strong, characteristic, unpleasant odour. Admixture of D.D.T. or B.H.C. dusts with food grain is not practised in Great Britain or the U.S.A., but is practised in some other countries. These dusts can be very useful for the protection of seed grain but, whereas D.D.T. will apparently not harm the germinating power, this may be upset on prolonged contact with B.H.C. As with the inert dusts, admixture with grain on a large scale is likely to give rise to irritating dust clouds, but considerable protection against infestation would no doubt be given by a surface treatment which would probably put less dust into the atmosphere. When bulks of grain have heated sufficiently to drive the insect infestation to the surface, considerable control could almost certainly be effected by a liberal strewing of dust over the heaps.

Compressed air injectors

Attempts have been made to introduce dusts, particularly B.H.C., by means of compressed air injectors into bulks or bags of grain, with differing claims of success. It would seem, however, that uniform injection is, *a priori*, impossible because the dust is mostly impacted on the grain within an inch or two of emergence from the injection tube. Even so, injection of bags of grain subsequently made into close piles may have a useful effect by virtue of the fumigant properties of the B.H.C. vapour, but little protection of the outer sacks in a pile could be expected.

B.H.C. dust has been reported effective for the sterilisation of used sacks by shaking a handful of dust into each sack and rolling the sacks up in tight bundles or in bales until required for re-use.

Finally, D.D.T. and B.H.C. dusts can be most useful for strewing over the floor of empty stowages after cleaning. Insects often remain inaccessible in floor cracks during cleaning and the application of a toxic dust can thus be very helpful in reducing cross-infestation. The dusts can also be laid down as barrier walls about 4 in. (10 cm.) across and 2 in. (5 cm.) high on the floor between infested and uninfested goods to prevent the migration of crawling insects. Either the uninfested or the infested pile, preferably the latter, should be completely surrounded by the barrier wall.

SMOKES

D.D.T. and B.H.C. smoke generators are available, containing the insecticide mixed with a slow-burning pyrotechnic composition. A certain amount of insecticide is decomposed during combustion, the remainder being dispersed in finely divided form in the smoke.

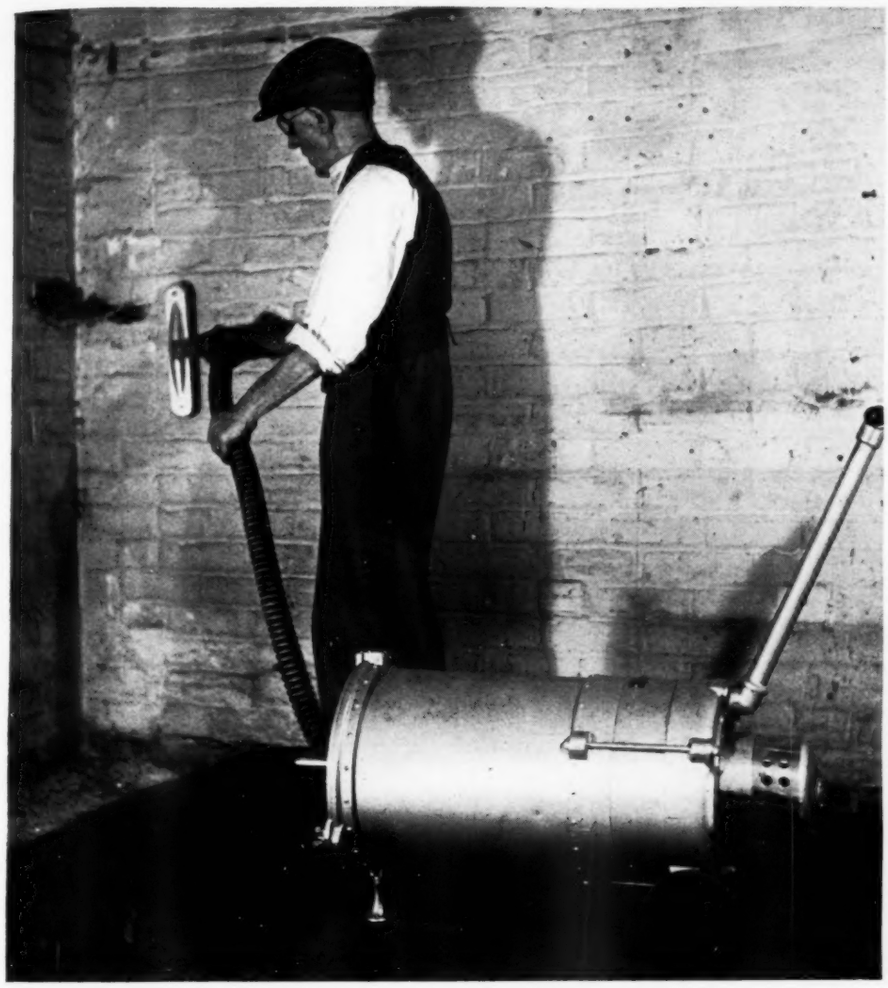
Different sizes of generators are made for treatment of different volumes of space, but more efficient distribution in a large space is obtained by using several small generators. They are easy to transport, simple to operate, and sealing of buildings, other than closure of doors and windows and the stopping-up of large gaps in the fabric of the stowage is not necessary. The smokes are dependent for their distribution upon convection currents and draughts and so have little penetrative power; thorough cleaning, therefore, is an essential preliminary to this form of treatment. There can be no control of deposit from smokes as there is with sprays and dusts, which can be applied more or less heavily to particular areas, as thought necessary. Little insecticide will adhere to vertical or inverted surfaces, most sedimenting on to the floor or other horizontal surfaces, giving deposits containing some 100 to 150 mg. D.D.T. per sq. ft. or 60 to 90 mg. B.H.C. per sq. ft., depending upon the shape of the space under treatment.

The fire risk during operation of smoke generators is negligible, but should always be guarded against by standing the generator in a bucket or on a large sheet of non-combustible material. Operators should carry a mask, fitted with a smoke filter, as a precaution and should light first the generators farthest from the exit. The stowage should be left closed for at least two, and preferably four or more, hours, before opening and dispersing by ventilation any remaining smoke.

The usual safeguards against tainting of foodstuffs must be taken and smokes are therefore of most use for treatment of empty stowages. In the course of a single treatment insufficient smoke penetrates grain sacking or other closely woven types to involve any immediate toxicological risk with the foodstuff, except, for example, when residual flour is recovered during the cleaning of 'empty' sacks. Nothing is yet known of the transfer of insecticide from smoke-treated sacking to the contents during subsequent storage; the protection of goods to be stored a few months or more and which cannot be temporarily removed should be secured, if necessary, by covering the horizontal surfaces with a tarpaulin or dust sheet.

IMPREGNATION OF SACKS

Impregnation of different types of sacking with about 1% by weight of D.D.T. confers considerable protection against insect infestation of the contents, especially if the sacking is of sufficiently close weave to offer some mechanical hindrance to penetration; almost complete protection is afforded by impregnation with 5% of D.D.T. Unfortunately, this control method can be employed safely only with foodstuffs consisting of large, almost unbroken units such as grains and cacao beans, for relatively large amounts of D.D.T. (up to 100 or more p.p.m.) can be transferred from the impregnated sacking to finely divided foodstuffs, especially if they are also oily—even when stored for only a few months at a temperature of about 20°C. This treatment, therefore, cannot be recommended for application to sacks intended to hold products like wheat flour, soya flour or decorticated groundnuts. On the other hand, D.D.T.-impregnated sacks might be very useful for the storage of seeds which are not intended for consumption. Impregnation by dipping is very wasteful of organic solvents, unless a centrifugal extraction plant is available, and water is unsatisfactory as a base, *e.g.* in emulsions, because it causes the sacks to shrink. There is need for information upon other methods of apply-



Removal of dust and debris from walls and floor with a vacuum cleaner prior to insecticidal treatment of an empty stowage

ing insecticides to sacking than by dipping, in relation to cost, toxicity to insects and contamination of foodstuffs.

CONTACT INSECTICIDES AND THE FUTURE

Contact insecticides already play an important part in the preservation of many stored foodstuffs from deterioration through infestation by insects and there can be no doubt that they will find increasing use. As more knowledge is accumulated about them their various advantages and disadvantages can be more clearly defined, and the best combination of insecticide, formulation and method of application chosen to suit a particular set of practical conditions. This choice, however, can be made only against the background of a detailed knowledge of the circumstances under which infestations have to be controlled.

Apart from developments of detail to improve the formulation and application of contact insecticides, there is wide scope for the discovery of compounds which have a high toxicity to insects but a much lower toxicity to man and animals than substances like D.D.T. and B.H.C. Such compounds could be used more freely in the presence of stored foodstuffs. New contact insecticides are also required to control certain pests like the larvae of the Khapra beetle, *Trogoderma granarium*, which are highly resistant to pyrethrins, D.D.T. and B.H.C. Nevertheless, the existing contact insecticides, if their uses are fully exploited, could cope with most of the problems of insect infestation in stored foodstuffs. While it is essential that research should continue to furnish scientific data on these insecticides, the quickest increase in saving of stored foodstuffs from deterioration due to insect attack would certainly come from wider dissemination of knowledge about contact insecticides already available and from their more extended use, provided that their application is combined with improvements in hygiene.

Contamination by residues

Until compounds of very low mammalian toxicity are available, continual attention must be paid to the likelihood of dangerous contamination of foodstuffs by residues of contact insecticides. Information upon the extent of direct and indirect contamination likely to be encountered under different sets of practical conditions and upon the toxicological importance of such contamination, is very difficult to obtain and is, as yet, very scanty. At the present time, countries differ widely in their attitudes towards possible contamination, and it would doubtless be unrealistic to attempt to get a set of tolerance limits accepted generally, without regard to the circumstances surrounding the storage of particular parcels of foodstuffs. For example, the risk to the consumer of even slight illness resulting from the treatment of grain intended for early consumption at a time of no shortage would have to be fully guarded against, whereas this risk would be of less importance in the treatment of grain for long-term storage as a reserve against famine, because spoilage or destruction of part of the grain through insect attack could itself lead to malnutrition and possibly deaths from starvation.

Conclusion

Finally, it is to be hoped that as the use of contact insecticides spreads, attempts will be made to determine the degree of success following different treatments under carefully defined practical conditions. Laboratory experiments can give good leads to what may happen in practice, but can never completely reproduce the conditions found in different types of stores, etc. By proper combination of laboratory experiments and field observations many gaps in our knowledge of the causes of success or failure of treatments with contact insecticides should be filled and, consequently, better use made of them in future.

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The Editor invites agricultural authorities, research workers and producers of crops throughout the world to submit factual articles likely to be of interest to readers of this journal with a view to publication. Illustrations (photographs, diagrams, charts, etc.,) should accompany contributions whenever possible. A preliminary letter or synopsis is desirable.

Trace Elements in Plant Nutrition

E. J. HEWITT, B.Sc.

Long Ashton Research Station, Bristol, England

Of late years the importance of trace elements in plant nutrition has become increasingly apparent. They are so called because they are needed by plants in only very small amounts compared with the major plant food elements. Nevertheless they are of great importance, and if they are lacking crops show signs of deficiency and symptoms of disease appear the cause of which was formerly obscure. In all, six trace elements are now recognised as being of major importance, namely, iron, manganese, copper, zinc, boron and molybdenum. The role of each and the effects produced by their absence in plant nutrition are discussed in this article.

PLANTS need several mineral elements for normal growth; some are required in relatively large amounts like the familiar group of nitrogen, phosphorus and potassium, to which may be added calcium, magnesium and sulphur. Others are needed only in very small amounts and are termed trace elements or more scientifically micro nutrients. Those known at present are iron, manganese, copper, zinc, boron and molybdenum. The usual content of iron or manganese in dried plant material (about one tenth of the fresh plant weight) is only about 100 p.p.m., or one hundredth of 1%. The normal amount of copper or zinc may be only one tenth of that of iron and the amount of molybdenum may be only 1 or 2 p.p.m. or even less. The fact that these elements are only needed in such minute amounts naturally arouses curiosity as to why they are so important for normal growth. No plant has been found to produce a good crop in their absence, and excess of any of them may also have drastic effects. In higher green plants no other elements, out of more than 90 known, appear able to replace the functions of these six essential micro nutrients.

Knowledge of the role of these trace elements has been of great practical value. It has shown which crops have the greatest requirements for each element and has also explained the nature of a number of of plant maladies which were formerly obscure.

The green mantle

Green leaves are one of the most familiar features of plant growth; they are the organs of photosynthesis, whereby the energy in sunlight is absorbed and carbon dioxide and water are converted into food reserves—sugars and starch. The greenness is due to chlorophyll pigments, which are highly specialised energy-converting compounds. Chlorophyll contains magnesium, an element essential to its existence; equally essential is iron, although this element is not actually part of the chlorophyll molecule. When iron is deficient the condition of *chlorosis* occurs, and shoots, especially leader shoots in trees like apples and pears (Fig. 1), and terminal growth or younger leaves in soft fruits, become pale green or even yellow, while the older leaves and basal spurs may remain normal. All the leaf veins, including the finest, appear clearly outlined. Fruit trees are especially susceptible to chlorosis caused by lack of iron and this disorder is particularly serious for these crops. When severe the leaves not only fail to perform their true function of photosynthesis, with consequent weakening of growth, but scorching of the leaves and die-back of the shoot occurs.

The precise part played by iron in chlorophyll formation is still unknown. It is essential also for enzymes (organic catalysts that direct the reaction of living tissues) controlling respiration processes whereby sugars and proteins are converted to carbon dioxide and water with release of energy, but it is not known if this function is related to or even competes with that of chlorophyll formation. The structure of the chlorophyll molecule bears a striking resemblance to part of the iron-containing red blood pigment haemoglobin to which the iron is attached, and the suggestion has been made that existence of this type of structure is the reason for the need for iron in chlorophyll formation. So far, however, all attempts to produce chlorophyll by supplying plants with 'intermediates' of this nature in the absence of iron have failed.

Most mineral deficiencies are identified by the typical visual effects produced, by the response to sprays or application to the soil of the deficient element and by chemical analysis of the plant material. Iron deficiency is readily identified by the first and second tests, although analyses

Fig. 1—*Iron deficiency chlorosis in apple. Note fine pattern of veins and chlorosis at shoot tip*

frequently give no indication of deficiency. In other words, the iron is in some way immobilised or unreactive in the leaf. Straightforward lack of iron in field or orchard crops is extremely rare.

Calcareous soils frequently cause ' lime-induced chlorosis '; this disorder is of widespread importance in orchard crops. Potassium deficiency may also induce iron deficiency chlorosis, especially in plum and *Citrus* trees. Soil applications of iron compounds may be unsuccessful and sprays often cause injury, but injection into trees of solid iron compounds is often satisfactory.

Instances of chlorosis and injury caused in vegetable crops by the presence of excess of metals like copper and zinc in sewage sludge or in the soil are also known. In affected plants the iron content may be abnormally high—this is further evidence of the plant's inability to utilise iron already taken up by the roots. The fact that iron deficiency symptoms are induced by excess of these metals essential in small amounts, further illustrates the complexity of the interrelationships of the trace elements.

Fig. 3—*Boron deficiency in sugar beet. Death of main growing point and ' heart rot ' cavity. Multiple shoots arise round the crater*

The manganese balance

The term trace element may at times be misleading for in some circumstances, especially under conditions of soil acidity, so-called trace elements may be available to plants in excessive amounts that cause injury to many crops. This is particularly true of manganese, which may vary in concentration a thousandfold. In acid soils, manganese (and also excess of aluminium) may cause many economic crops to fail and typical leaf malformations and breakdown occur. A disorder in apple trees in the United States knov n as ' internal bark necrosis ' has been attributed to manganese toxicity. Excess of manganese may induce iron deficiency and this happens with pineapple growing in very acid or manganiferous soils as in Puerto Rico or Hawaii.

Fig. 2—*Manganese deficiency in apple. Note bold ' herring bone' pattern and general distribution of the chlorosis*

The availability of manganese is very sensitive to soil reaction and *p*H values between 6.5 and 8.0, especially with free calcium carbonate, may induce manganese deficiency, particularly if there is much organic matter in the soil or a fluctuating water table. Soil applications are often ineffective and spraying or injection methods are preferable. Oats, beet, peas and potatoes are especially susceptible, and some fruit trees, particularly apple, may suffer badly.

The functions of manganese in plant metabolism seem to be complex. Manganese is necessary for the maintenance of chlorophyll in leaves, and depletion or absence of manganese causes chlorosis, but the characteristic pattern around the major veins, which are often boldly outlined by a region of dark green tissue (Fig. 2), differs from that caused by iron deficiency; in some crops such as beans and oats, leaf breakdown from this cause is extensive.

The role of manganese has been regarded as related to that of iron in plants, since excess of manganese can induce iron deficiency. Frequently, however, other quite distinct effects occur and as a single plant can show simultaneously symptoms of deficiency of both elements it is clear they have at least some independent functions. Manganese can actuate several enzyme systems and appears to stimulate respiration as shown by carbon dioxide production, and is also essential for the reduction of nitrate, which constitutes a great part of the nitrogen taken up from a fertile soil.

The importance of boron

The essential nature of boron has been recognised for nearly 40 years and many economic crops show acute disorders when boron is deficient in the soil. Examples are ' heart rot ' in sugar beet (Fig. 3), ' canker ' in table beet, ' rahn ' in swede, ' water core ' in turnip and ' stem crack ' in celery. Many root crops, Brassicae and legumes are particularly sensitive to it, while cereals are the most resistant. Boron deficiency is associated with highly calcareous soils or overliming, especially on formerly acid, sandy soils or soils derived from the older rocks. The deficiency is easily remedied by soil application or injection, but many crops are easily injured by excess and the dressing of boron required to cure acute deficiency in sugar beet may be toxic to potatoes.

Boron deficiency is not known in orchard crops in Great Britain, but is an important problem in these crops in Finland, Switzerland, Canada, the United States, Australia and New Zealand. Apples are par-

ticularly affected and boron deficiency is known also in pears in Switzerland and Australia. Shoot die-back and ' bark measles ' are effects seen in the trees. The effect of boron deficiency in apples is shown particularly in the fruit and disorders, sometimes referred to as dry weather diseases, are produced. These include ' drought spot ' and ' surface cork ' on the exterior and ' corky core ' and ' internal cork ' inside the fruit. A distinct disorder, also of a physiological nature, known as ' bitter pit ' or ' corky pit,' occurs in Great Britain and elsewhere but does not respond to applications of boron as do the other disorders mentioned.

The apricot is an example of a sensitive stone fruit type; brown spotting of the fruit near the stem end has been recorded as a boron deficiency effect in New Zealand. Boron deficiency occurs in grapes in the United States, Australia and New Zealand. The fruit is also the part most noticeably affected: parthenocarpy with seedless fruit, poor fruit set and disorders of the fruit flesh may occur. Cherries may also show effects such as splitting of the fruit after rainfall, attributed to non-elasticity of the membranes due to lack of boron. The *Citrus* species also have marked boron requirements. Deficiency causes an effect known as ' Psorosis ' of the bark, gumming in the vessels and destruction of the *phloem*, a specialised type of conducting tissue. Multiple buds, corky splits across the leaf veins, and hard fruits are also produced.

The role of boron is again most readily appreciated by studying effects of its deficiency. A frequent type of response is derangement of the growing point of the main shoot. The growing point may be killed, lateral shoots become active and are in turn killed. This leads to plants with a bushy habit and numerous dead or weak growing points.

The growing point of a shoot is an example of a *meristem* or group of specialised but undifferentiated cells which rapidly divide to produce new tissues. Most plants have several meristematic regions. Other meristems include root tips, cork-forming and bark-forming layers, and the *cambium* layers in stems and roots, responsible for increase in girth and formation of storage tissues. Lack of boron affects different meristems in different plants. The ' rahn ' in swede, ' water core' in turnip and ' canker ' in table beet are examples of disorders in the root cambial zones. ' Heart rot ' of sugar beet is due primarily to death of the main growing point, which leaves a hollow surrounded by numerous secondary shoots. The hollow collects water and encourages bacterial rots.

Fig. 4—*Zinc deficiency causing ' little leaf ' in apple tree. Right hand side showing typical little leaf and no setting. Left hand side normal after application of zinc sulphate sprays*

Boron deficiency in legumes causes death of the growing point and root tips. The root nodule bacteria, responsible for symbiotic nitrogen fixation in leguminous plants, tend to become parasitic when the host legume is unable to obtain adequate boron owing to inability to produce the vascular tissue required to supply the bacteria with food materials. Boron has also been found essential for the germination of pollen grains and the growth of the pollen tube.

Boron toxicity may also occur, especially in parts of the United States, where irrigation is practised. Stone fruits are particularly susceptible and gumming, bark necrosis and death of the shoots occur. Unlike most crops where boron accumulates mainly in the leaves, stone fruit may accumulate boron in the fruit. There is some evidence that the uptake of boron (as of some other elements like magnesium) is controlled more by the root stock than the scion growing on it.

The precise function of boron in plants is still obscure. It has been suggested that one function is to maintain calcium in a soluble or available state within the plant, as many plants show similar symptoms when either calcium or boron are deficient. There are, however, some important distinctions. When boron is lacking, accumulation of sugars and other carbohydrates and of soluble nitrogen compounds such as amino-acids occurs, and it is therefore inferred that boron is necessary for the combination of these compounds in the formation of proteins.

Zinc deficiency

So far the trace elements considered have been those required in the relatively greatest amounts. The last three are present in much smaller quantities, but two of them, namely copper and zinc, have particular significance among orchard crops and other economic crops. The effects of zinc deficiency were recognised for many years as the disorder of *Citrus* trees known as ' mottle leaf,' before the cause was identified. In fact the earliest attempts to produce a cure were made by applying iron compounds as a spray to the foliage, with markedly beneficial results. Later experiments traced this apparent response to iron to the presence of zinc impurities in the iron compounds and the equipment used, which shows the care required in studying these sensitive and difficult problems.

Zinc deficiency is widely distributed. Maize shows the disorder called ' white bud ' and many orchard crops are especially sensitive. *Citrus* species, several stone fruit such as cherry, plum, peach and apricot, apples and grape may all be seriously affected, as also are pecan nut and many vegetable-oil-producing trees. Zinc deficient areas occur in several parts of the United States, Australia, Holland, Denmark and Hungary, and very recently their occurrence in Great Britain has also been confirmed.*

The soil conditions responsible for zinc deficiency are sometimes complex. Neutral

*T. Wallace and others: *Nature*, 1949 (in the press).

soils are more susceptible than acid ones and the content organic matter appears to be a factor. The ' corral ' soils in Florida are especially liable to zinc deficiency. The activity of micro organisms believed to ' fix ' zinc in competition with the roots of plants has been suggested as a factor leading to zinc deficiency, while highly leached sandy soils may also be deficient in the element.

The symptoms are frequently characteristic and are described by the terms ' little leaf ' or ' mottle leaf '; it is exhibited in apples (Fig. 4), in *Citrus* trees and in the stone fruits; ' pecan rosette ' and ' bronzing ' of tung are examples. The foliage is abnormally narrow and small; leaf margins are curled and the leaves are mottled; shoot growth is rosette in habit, as for example, in ' pecan rosette ' and in

Fig. 5—*Copper deficiency in wheat. Note the rolled leaves and the failure of terminal part of the ' ear '*

apples where numerous multiple shoots produce a ' witch's broom ' effect. Frenching of the leaves may also occur in *Citrus* and the fruit is unpleasant to the taste.

The effects of zinc deficiency may be discerned also in microscopic disorganisation of the tissues. The contents of leaf cells become shrunken and phenolic compounds accumulate. Increased cell size may also occur and the chloroplasts which are responsible for carrying the green chlorophyll pigment are destroyed. Seed setting is reduced even in plants which show no other visual effects.

It was mentioned earlier that excess of zinc may induce iron deficiency. This may be serious in fruit such as apple, raspberry and strawberry where zinc-bearing minerals occur in the soil.

Zinc is thought to be essential to oxidising enzyme systems. Absence of zinc may be partly mitigated by supplying additional quantities of auxin (one of the plant growth hormones) to the shoots and, in the absence of zinc, auxin may be inactivated or destroyed. Zinc has also been shown to be essential for the enzyme called carboxylase, which catalyses the reaction between carbon dioxide and water to form carbonic acid solution. This reaction may be of importance in controlling respiration rates or, in reverse, photosynthesis.

Copper deficiency

Copper deficiency occurs mainly in two groups of crop plants, viz. the cereals and orchard crops. In cereals a disorder long known as ' reclamation disease,' ' heather moor disease ' or ' white tip disease ' is due to it. Symptoms include tightly rolled white leaf tips and disintegration of the chloroplasts, sudden death of the immature floral spikelets before emergence or, when less severe, failure of the ' ear ' to fill with grain (Fig. 5). ' Reclamation disease ' is prevalent on reclaimed moorland soils in Holland and Denmark and elsewhere. The Everglades soils of Florida are analogous to the peat soils just mentioned and the beneficial effect of Bordeaux sprays was the clue to the presence of widespread copper deficiency in several crops. The sandy coastal plain soils in Australia are also copper deficient, and cereals, flax and pastures are affected.

These two types of soils differ with respect to the amounts of copper required for control of the deficiency. The former may need a hundredweight to the acre, the latter only about 14 to 20 lb. This difference is related to the nature of the soils. The former are organic soils with a high fixing capacity for copper which is rendered unavailable, the latter are leached and suffer from straightforward deficiency.

Fig. 6—*Molybdenum deficiency in cauliflower showing effects resembling ' whiptail '*

In regard to orchard crops copper deficiency in deciduous fruits is prevalent in South Africa, New South Wales and Western Australia, where the trouble is regarded as one of the most serious nutritional problems in the growth of *Citrus* fruit, pears and Japanese plums, and in the United States where apples, pears, *Citrus* fruit, French prunes, Avocados and tung oil trees are all seriously affected.

The disorders are given various names but ' exanthema ' is a term commonly applied to pears and *Citrus* fruit. ' Exanthema ' or ' die-back ' of *Citrus* fruit causes gum formation, bark necrosis, staining of the shoots followed by die-back, multiple shoots and angular branching; the foliage later becomes unusually dark green, thickened and narrow in outline like peach leaves and the fruit is marked. Die-back and defoliation occur in ' tung chlorosis ' and apples show ' summer die-back ' or ' wither tip.' The habit is bushy and stunted, the foliage is narrow and readily defoliates. Tinting of the shoot and multiple buds occur in 'Avocado die-back.' Excess of copper induces chlorosis effects identical in appearance with those caused by iron deficiency.

The function of copper appears to be related to its function as a co-enzyme in polyphenol oxidase, an important enzyme in respiratory activity, which catalyses the oxidation of phenolic compounds and is responsible for the browning of many tissues on exposure to the air. Copper is also said to be present in ascorbic acid (vitamin C) oxidase, and this may account for its great importance to *Citrus* species. The site of polyphenol oxidase has recently been located in the chloroplasts in spinach plants and the vital importance and complexity of function of these minute bodies is thus further emphasised.

Molybdenum's role

Molybdenum deficiency has only been recognised in higher plants in culture experiments since 1939, but since then it has been identified in the field in relation to nitrogen fixation in soils by the free *Azotobacter* and by the symbiotic bacteria in legume root nodules. Lack of available molybdenum prevents these organisms from fixing nitrogen and symptoms of nitrogen deficiency due to this cause have been found in poor acid pastures. Normal growth is restored by dressings of nitrate of soda, or frequently by liming or by apply-

ing as little as 1 oz. or less per acre of sodium molybdate.

More recently it has been shown that Brassica crops have relatively high molybdenum requirements and the symptoms of a long-known disorder of cauliflower and broccoli called ' whiptail ' have been reproduced in sand culture experiments by the careful elimination of molybdenum (Fig. 6). Reports of field experiments from Australia and New Zealand also show that ' whiptail ' type plants respond to dressings of sodium molybdate at rates between 1 to 8 lb. per acre.

No naturally occurring molybdenum deficiency effects have been recorded in orchard crops, although *Citrus* and plum trees have been shown to need this element in water culture experiments.

The circumstances associated with molybdenum deficiency differ from those of the other micro nutrients in that soil acidity appears to reduce the availability of molybdenum and natural supplies are usually adequate after liming. Phosphate also seems beneficial to molybdenum uptake. Molybdenum is essential in the reduction and assimilation of nitrate by plants as well as for the bacterial fixation of nitrogen. The production by the plant of free amino-acids is reduced by molybdenum deficiency, and leaf formation and shape are also abnormal. The role of molybdenum is related to that of manganese, which has an opposite effect on amino-acid concentration.

Conclusions

It is evident that the trace elements have important functions in the growth of plants and affect many aspects of their metabolism; deficiency or excess of these elements leads to characteristic disorders. Deficiencies of the trace elements are usually associated with particular soil conditions. Neutral or alkaline soils are more prone to deficiencies of all the trace elements except molybdenum, which is less available in acid soils. Plants growing in peaty soils or those rich in organic matter are liable to show effects of lack of copper and manganese, the latter especially after liming. Calcareous or over-limed soils may be deficient in boron, iron and manganese. Micro organisms may be responsible for non-availability of zinc in some soils and also for the oxidation of manganese to an ultimately non-available form. Orchard crops show effects of all these deficiencies except molybdenum. Most of the disorders so caused can be controlled by spraying or injection techniques, which usually cost little in comparison with the resulting improvement in yield.

All photographs in this article by courtesy of Long Ashton Research Station.

Agriculture in the Republic of Ireland

BY the end of September it was clear that a more than normally favourable season had resulted in excellent agricultural yields for practically every crop grown in Ireland, although the acreages sown were below those of the previous year.

Corn crops

The acreages under the various corn crops in 1949 (preliminary figures) were as follows:

Crops	1948 *Acres*	1949 *Acres*
Wheat	518,400	357,700
Oats	880,100	682,900
Barley	119,800	154,500
Rye, beans and peas	9,300	2,500
TOTAL CORN CROPS	1,527,600	1,197,600

Supplies of machinery were adequate. Shortage of labour did not present a serious problem, as harvesting operations were carried out with a minimum of effort in the favourable weather.

Harvesting and threshing of all crops was completed by the end of September.

Winter wheat.—Yields were considerably better than those of 1948 and condition and quality of grain were excellent.

Spring wheat.—Yields were generally higher than those of last season and condition and quality of grain were of a very high standard.

Oats.—Yields were below average and, although the grain was harvested in good condition, the quality was not entirely satisfactory.

Barley.—Both in yield and quality of grain the crop was one of the best for a number of years, which resulted in a surplus of grain for malting.

Root and green crops

The acreages under root and green crops, 1949 (preliminary figures), were as follows:

Crops	1948 *Acres*	1949 *Acres*
Potatoes	385,400	346,100
Turnips	153,000	137,000
Mangels	82,100	77,400
Sugar beet	66,400	59,500
Cabbage, etc.	37,000	35,200
TOTAL ROOT AND GREEN CROPS	723,900	655,200

Potatoes.—Only limited diggings of main crop varieties had taken place by the end of September. Yield prospects were variable, but were generally expected to be up to average. Outbreaks of blight were widespread, but were not severe except in a limited number of areas where some blackening of tubers had taken place. Common scab was more prevalent than usual and second growth, although evident in most crops, was not serious.

Turnips.—Early sowings continued to make good growth and should produce average yields. Later sowings made fair progress, but roots were still small. Crops were generally healthy. There were some isolated cases of mildew and some dry rot which followed turnip midge damage.

Mangels. — Crops made satisfactory progress under favourable weather conditions and yields were likely to be well up to average.

Sugar beet.—Crops continued to improve and satisfactory yields were expected.

Seed production. — Threshings of cruciferous seed crops were completed early in September. Condition and quality of seed was good and yields were well up to average. Threshing of mangel seed crops was in progress and yields were likely to be satisfactory.

Other crops

Rye grass seed.—The bulk of the crop was threshed during September. Yields varied from 5 to 10 cwt. per statute acre and the quality of the seed was good.

Pastures.—Pastures, especially those which received dressings of artificials earlier in the year, made very good growth and were carrying an excellent covering of grass at the end of September. Aftermaths continued to improve and are expected to afford good keep for livestock well into the winter.

Haymaking.—Storing, which was completed in some districts, was generally much more advanced than at the end of September, 1948. Yields on the whole were below average, but the general quality of the crop was excellent.

Recent Advances In Tea Research

Tea rollers and Legg cutters, Kumargram factory, Dooars, Northern India [*Photo: Empire Tea Bureau*

III—Manufacturing Processes

T. EDEN, D.Sc., A.R.I.C.

Director Designate of the East African Tea Research Institute

During recent years new ideas have tended to revolutionise traditional methods of tea manufacture. How far these new ideas will achieve wider adoption it is not yet possible to gauge. After describing these new methods in this, the third and last of his series on tea, Dr. Eden attempts to forecast possible future trends in the cultivation and processing of tea.

THE fundamental process involved in changing fresh green leaf into black tea is fermentation. The so-called tannin in the tea leaf is oxidised through the agency of an enzyme, also present in the leaf, when brought into contact with air. It is the purpose of the various processes of manufacture to bring about this chemical change in such a way as to produce a tea having good colour, strength, pungency and flavour.

Investigations on the chemistry of the green leaf and the changes it undergoes have been carried out in all the major research stations; and for work on the finished product, India, Ceylon and the Netherlands East Indies have combined to support a chemical research project in London. The whole subject of tea chemistry, especially in its relationship to quality, is exceedingly complicated, and only a small part of what happens in the process of manufacture has as yet been elucidated. In barest outline, the following is a summary of the established results of these researches.

'Tannin'

The name 'tannin' is a misnomer when applied to the fermentable constituents of the tea leaf. They are catechin polyphenols belonging to a different group from those which are commonly termed tannin, and their characteristics no more resemble those of tannins than, for example, the ethyl alcohol of potable liquor resembles glycerine, though both are alcohols. Much misunderstanding has been caused in the past by this confusion. The enzyme of the leaf is a typical polyphenol oxidase of the copper-protein type. Leaf from different bushes varies in enzyme content and activity, and non-fermenting bushes have been found that contain only about a fifth of the quantity of enzyme present in adjacent bushes. Abnormal leaf can be made to ferment if additional copper is supplied to the living plant by spraying or inoculation. Tea which suffered from a soil copper deficiency in Nyasaland and was subnormal in fermentation capacity has been rectified by occasional spraying. The copper deficiency does not affect the growing capacity of the bush and does not bring

about a disease comparable in type to tea yellows.

The oxidation of the catechins produces orthoquinones which with their condensation products are responsible for the coloured extract recognised in a brew of tea. At the same time, the green chlorophyll of the leaf is oxidised to brown products by the orthoquinones which are thereby reduced to catechins once more. These two reactions account for the coppery colour of fresh fermented tea. They may be expressed diagrammatically as follows:

$$\text{Tea catechins} + \text{oxygen} \xrightarrow{\text{Polyphenol-oxidase}}$$

$$\text{Orthoquinones} + \text{chlorophyll} \longrightarrow \text{Tea catechins} + \text{chlorophyll oxidation products}$$

What relationship exists between the oxidation products and quality in tea is unknown, but given standard leaf from a particular estate that is subject to a standard process of manufacture, high polyphenol content and price valuation are positively and significantly correlated. In Ceylon, enzyme activity is highest in the dry weather and lowest immediately after the onset of the rains, the times of quality and plain teas respectively. Coarse plucking diminishes both polyphenol and enzyme content. To sum up, polyphenol content and enzyme activity together give a working criterion for assessing by chemical means the potentiality of leaf for producing good tea. The work carried out so far shows unmistakably that good tea is made in the field. It can be spoiled in the factory, but no refinements in manufacture can create quality from inferior leaf.

Traditional manufacture

The traditional processes of manufacture are withering, rolling, fermenting and firing. In the first, the loss of up to 45% of its weight by evaporation, besides bringing about certain biochemical changes in the leaf, prepares the leaf for rolling. Thereby, the leaf juices are made to exude and cover the leaf surface. Fermentation with evolution of heat starts in the roller and is completed on the fermenting table. Firing dries the fermented leaf and by killing the enzyme stops further fermentation. Because fermentation is of the essence of the manufacturing process, the implications of withering and rolling have lately received much attention, not only from the research stations but from engineers and factory superintendents.

Standard rolling

The standard rolling equipment of a tea factory merely mechanises the crude process of hand-rolling, palm on palm. An open-ended cylinder or ' box ' is suspended with a small clearance over a circular ' table.' The box is made to circulate over the table by means of a crank. Size of box table and crank-throw are carefully correlated. The leaf in the box is twisted by the roller friction and this friction can be increased by applying a pressure cap to the box and by corrugating the roller table by means of variously shaped battens.

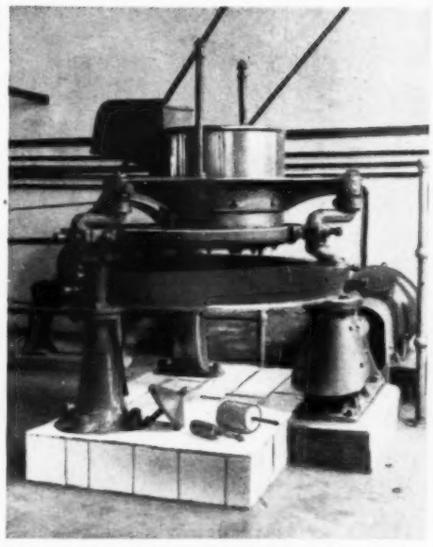

Fig. 1—*Experimental roller and epicyclic fittings*

Fig. 2a—*Clivemeare roller for witherless tea manufacture*

It is important to twist the leaf first with a minimum of breakage, and, consequently, the work done on the leaf is low at the start and is increased by increasing pressure later. When pressure is applied the heat of fermentation is confined and therefore pressure rolling is carried out intermittently with equal periods in which pressure is released. A standard rolling process would consist of about 20 to 30 min., made up of alternating periods of 5 min. with and without pressure. At the end of this time the leaf is removed, sifted to remove the comminuted portions (dhool) and to cool the leaf mass, and then again subjected to further rolling. As few as three of these rollings or as many as five have been commonly in use, depending on circumstances.

Rolling after this fashion is mechanically inefficient. The use of a pressure cap inhibits leaf movement and confines the heat. Most of the work is done near the centre of the table. Lately, a modification of traditional rolling has been introduced to overcome these disadvantages.

Epicyclic rolling

The new development abolishes pressure caps. In their place a fitting of varying design has been fixed at the centre of the table (Fig. 1). As the box revolves, the gap between this fitting and the inner surface of the box traces an epicyclic pattern. It is the squeezing that the leaf gets as it passes this gap that constitutes the greater part of the work done on the leaf. By adjusting the size of fitting, the gap and the work done are correspondingly altered. It is not at present claimed that the ideal design for the epicyclic fixture has been attained and ' home-made ' fittings are frequently most unsuitable, but epicyclic rolling has been largely adopted commercially in Ceylon. It has both advantages and disadvantages. On the credit side is the increased efficiency of the power used and the shortening of the rolling period. The movement of the leaf through the gap and round and over the fixture is free, and supervision of pressure periods is entirely obviated. Dissipation of heat during rolling is adequately ensured. On the debit side is the relative rigidity of the process. Great care is needed in choosing fittings so that the leaf is not broken up too early in the rolling process. If this happens, flaky teas are produced. Withering, too, has to be more carefully standardised for, whereas the roller cap gives some flexibility in adjustment when leaf is under- or over-withered, this is not possible with epicyclic fittings. Although epicyclic rolling demands rather different skills for success, there is no reason to suppose that with experience it will prove more difficult to carry out.

Witherless tea manufacture

The space demanded by withering lofts, the cost of spreading leaf and the fire risks involved in factories filled with large expanses of jute hessian, have posed the question whether withering can be entirely abolished. If whole unwithered leaf is

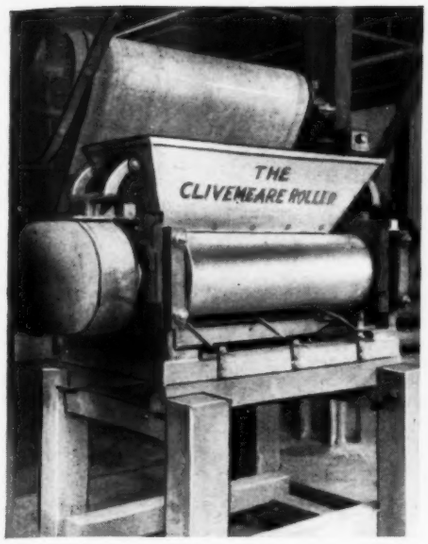

Fig. 2b—*Front view of the Clivemeare roller*

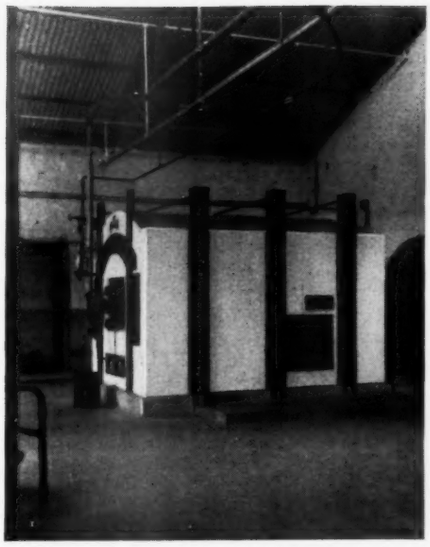

Fig. 3—*Direct firing furnace for drier*

rolled by standard equipment it is not twisted, but merely broken. The juices are not exuded and fermentation is ruined. Rolling ruptures comparatively few cells but does increase their permeability. If withering is superseded then a technique of positive cell rupture is needed. This is provided by two new machines which have recently been tried on a commercial scale. Though differing in detail, they are similar in principle. Essentially, the unwithered leaf is squashed between smooth cylindrical rollers rotating inward with a very fine clearance (Fig. 2). Crushing is so efficient that the pulped leaf behaves as an absorbent surface and retains the juices without wringing out the liquid. The juices ferment rapidly and with quite surprising uniformity, and the infused leaf has a colour which surpasses in evenness the standard product. The liquors produced by this new technique are excellently reported on for colour and strength. The efficiency of the crushing is so great that some unfermented polyphenols are apt to find their way into the cup and to impart a tang of bitterness, but this difficulty is not insuperable.

From the point of view of commerce, the main objections are the unorthodox appearance of the finished teas which have no twist, and their low apparent specific gravity, which presents the trade with a packaging problem. Intrinsically, however, these teas are satisfactory and have good points of their own. Good appearance in traditionally manufactured teas is a useful guide whereby to assess good manufacture —a flaky, traditional tea has obviously been badly withered or badly rolled, frequently both. But once a radically different technique of rolling has been adopted, appearance ceases to be an adequate criterion.

So far, it has not been possible to assess the opinion of these teas on any suitable scale in the open market, but their future may be looked for with interest and a good deal of confidence.

As a variant on this witherless tea process, fresh leaf is sometimes shredded in a tobacco-cutter. In this process, the standard rollers are subsequently used to abrade the leaf further and give it the characteristic twist.

Drier design

Witherless teas reach the firing stage with more than twice the amount of moisture in them compared with those from normal manufacture. This makes efficient drying a very important matter; for a stewed tea is absolutely ruined. If witherless manufacture becomes usual there will doubtless be modification in drier design. One interesting feature has already been tried with success—the use of a direct heating stove. In the usual drier design, the hot air is obtained by drawing atmospheric air through a series of tubes which pass through a furnace. In the direct-fired heater, which is fitted only for use with liquid fuel, the actual products of combustion in the furnace are passed through the drying chamber and over the tea. This technique obviously demands perfect combustion, but this is not difficult to obtain. A drier of this type has been in use commercially at the Ceylon Tea Research Institute for more than four years (Fig. 3) with a 25% saving in fuel.

Looking into the future, it is tempting to try and forecast the changes that will take place in the tea industry in the next half century. Increasing cost of production is likely to drive poor estates out of production. There are three directions in which progress is needed. First, the renewal of fields with planting material of higher yield and quality. Second, the modification of the existing phase of monoculture, and lastly the mechanisation and systematisation of much of the labour of tea cultivation and manufacture. A basis for the first is already available. The second is a difficult but urgently needed development —how best to combine a conservational type of agriculture with an existing system of monoculture? In Africa, where virgin land is still available, the integration of arable annual agriculture and annual husbandry with tea culture offers a fascinating field for future endeavour. In the older tea areas, something might be done by concentrating production on restricted high-yielding areas and using the residue for conservation crops which could nevertheless contribute something to the tea areas in the nature of mulch and bulk manure. In the realm of mechanisation of cultivation, much depends on the lie of the land and on its liability to erosion. An over-enthusiastic approach without very careful research control might be disastrous. There is hope that mechanical plucking may prove satisfactory. At any rate, pilot experiments already in existence show that its possibilities must be taken seriously.

On the factory side, mechanisation offers plenty of scope for ingenuity. It may not be possible to get away entirely from producing tea on the basis of a batch process, though the writer believes a good deal could be done in that direction.

For Further Reading

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The Smithfield Show

The Smithfield Show is to be held from December 5—9 at Earl's Court, London.

A special feature of the show will be the display of agricultural and horticultural equipment, tractors and farm implements.

Land Use in the Wet Tropics

H. A. TEMPANY

(*Late Agricultural Adviser to the Secretary of State for the Colonies*)

The super-humid tropics present special problems of land-use; the heavy and continuous rainfall, high humidity, and high temperature produce the typical conditions that differ markedly from those of sub-humid regions, with heavily leached soils and rapid disappearance of organic matter when drainage is unimpeded; when drainage is impeded leaching is restrained, mineral fertility is higher, and organic matter accumulates; the soils are heavier and in their natural condition often unusable, but when reclaimed by drainage they may be of great value and have a wider range of uses than upland soils.

On uplands, permanent orchard crops are the most suitable form of cultivation as they permit the nearest approximation to natural conditions although limited possibilities in other directions exist. In alluvial lowland areas, although orchard crops may grow well, annual crops can be grown; in particular, rice is well suited to such conditions, other annual crops can also be grown, and there is some scope for animal husbandry. On this account these regions are specially important from the point of view of food supply.

Correct land-use is essential in view of growing populations and demands for food, and on this account the limitations imposed on land-use as a consequence of conditions must be recognised.

IN the super-humid tropics of the equatorial regions the effective rainfall exceeds 80 in. per annum; the incidence is seasonally variable but it is unusual for any month to be completely rainless. The high rainfall is associated with high temperatures, with comparatively small annual and daily ranges, and high atmospheric humidity.

The characteristic conditions may be modified by geographical location and by land configuration; they occur most widely in South-East Asia, in Equatorial Africa, in the South and Central American regions, in the Caribbean area and in the Pacific. The climatic factors are responsible for the soil and vegetational conditions and determine the agricultural uses to which the land can be put.

As the rainfall exceeds the evaporation the soils are pedalfers; drainage is of great importance, and the soil-vegetation complex varies according as it it is free or impeded. Where it is unimpeded, as in mountainous or undulating upland regions, the soils are usually heavily leached and poor in mineral plant-food. Their character is affected by the nature of the parent rock; geologically old rocks, especially sedimentary rocks, give soils poorer than those derived from recent volcanic intrusions, whilst basic rocks give richer soils than acidic rocks high in silica. Nevertheless, under the climatic and vegetational influences, soils of approximately similar type can be produced from widely differing materials.

Fig. 1—*Unproductive soil at Serdang, Malaya. Planted in maize without manure*

Fig. 2—*Same soil as in* Fig. 1, *planted with maize and dressed with complete fertiliser*

The vegetational climax is tropical rain-forest with heavy production of organic matter, which breaks down rapidly, liberating carbon dioxide and facilitating decomposition of soil minerals. Most usually, weathering leads to the elimination of silica and the formation of siallitic soils and subsoils yellow to bright red in colour and markedly acid in reaction.

The concept of the soil catena formulated by G. Milne[1] and developed by C. G. T. Morison and his co-workers[2, 3] is probably of particular significance in the super-humid tropics. Eluvial conditions will probably extend farther down slopes and colluvial conditions be more restricted than under sub-humid conditions, and this will affect land use, since markedly eluvial conditions are unfavourable to crop growth. Fig. 4, taken in southern Malaya, illustrates how the growth of young rubber can diminish as one proceeds up a slope and conditions become progressively eluvial.

Where drainage is impeded conditions are different. Vallev bottoms, alluvial flood-plains of rivers and coastal alluvial flats provide examples. Leaching is largely arrested, accumulations of finer material transported from higher regions, giving closer textured soils. The vegetational climax may be swamp forest or swampy reed growth; in coastal regions it may be

mangrove swamp. Conditions are often anaerobic, accumulations of peat occur in places and decay of organic matter is slower. The soils show great variability; often in an undrained condition they are infertile and contain toxic ferrous compounds, and sometimes the existence of ferrous sulphide leads to the formation of free sulphuric acid. Very often they are black or bluish clays and in coastal regions they are frequently highly impregnated with salt. In an undrained condition they are of little value, but when reconditioned by drainage they may be of considerable fertility.

In regions where active volcanoes occur, as for example in Java, Central and South America, and some of the West Indian islands, the periodic deposition of volcanic ash may affect soil fertility, masking the leaching effect on upland soils and enhancing fertility on lowland areas.

Organic matter and nitrogen

Under conditions of unimpeded drainage organic matter disappears with extreme rapidity, the high temperature and humidity favouring intense biological activity. In tropical rain forests, notwithstanding that organic matter is constantly added to the soil in large quantities (Vageler[4] estimates the amount as approaching or even exceeding 100 tons per acre per annum), there is no accumulation of a deep surface-layer of humus, in fact it is doubtful whether humus, in the sense accepted in temperate climates, is formed at all.

Closely connected are organic matter and soil nitrogen. The soil gains nitrogen through the agency of leguminous plants, and usually through the activities of free-living nitrogen-fixing bacteria (strains of azotobacter tolerant of the high acidity of the soils of the humid tropics have been shown to exist in Malayan soils by Altson), but their exact importance is still unsettled. Soils lose nitrogen through absorption by living plants, leaching and denitrification. Owing to leaching there is no accumulation of nitrates in the surface-layers of the soil as occurs during dry weather in the sub-humid tropics. Wilshaw[5] has shown that under Malayan conditions great fluctuations occur in the soil nitrogen-content within short periods and the position is highly dynamic.

The carbon/nitrogen ratio is also important; carbon supplies energy for soil organisms and a correct balance in this regard is essential; if it falls too low the supply of nitrogen for growth is disturbed.

Under natural conditions in tropical rain forest the soil-vegetation complex is a balanced system forming a closed cycle: Mineral plant food is brought from deeper levels by the roots of trees and incorporated in the surface-layers through the fall of plant remains. The carbon/nitrogen ratio is also maintained in a balanced condition, whilst erosion losses are held in check by the natural vegetational cover. So long as the cycle is maintained unbroken the position is stable and the vegetational cover retains its exuberant character which, incidentally, is responsible for the long-sustained but erroneous belief in the well-nigh inexhaustible character of the fertility of the soils of these regions. Actually the balance is one of extreme delicacy and when it is interrupted by clearing and cultivation, deterioration sets in unless measures are taken to prevent it. Organic matter rapidly disappears and the carbon/nitrogen balance is upset, the mineral plant food elements concentrated in the surface-layer become depleted and erosion losses of great magnitude occur.

Obviously land utilisation should be directed to preserving so far as possible conditions approximating to those which obtain in nature, and this limits the uses to which they can be put.

Low-lying regions have a wider range of potentialities owing to their greater reserves of mineral fertility, better status in regard to organic matter and reduced liability to erosion. The natural factors at work are similar to those in upland regions and agriculture must be directed towards conserving resources, but the margin is wider and the range of uses correspondingly more extended. On balance they represent the greatest asset of the super humid tropics.

Fig. 3—*Same soil as in* Fig. 1, *planted with maize and dressed with farmyard manure*

Land-use in upland regions

The type of agriculture suited to these conditions is that of permanent crops such as rubber, coffee, tea, cocoa and oil palms. The point has been recognised by many authorities: Stockdale,[6] writing with reference to Malaya, points out that orchard or tree crops offer greater possibilities than the cultivation of annual crops; Engledow,[7] writing on land use in the British Colonial Empire, has stressed the same point; F. J. Martin[8] called attention to it in regard to Sierra Leone and advocated the discouragement of the cultivation of annual crops on the uplands and the encouragement of swamp rice and other annual crops on the low-lying swampy lands, and this recommendation was adopted as the official agricultural policy of the Sierra Leone Government.

Permanent crops facilitate approximation to natural conditions, but even so special precautions require to be observed. The maintenance of the supply of organic matter is essential, equally so are soil-conservation measures immediately the forest cover is removed. Formerly it was

current practice to burn timber and brushwood immediately after clearing, thereby leaving the bare soil exposed to erosive influence, whilst the ash from the burn was liable to be washed or blown away. Recent practice, however, favours stacking the timber in lines and leaving it to decay under natural influences, thereby conserving organic matter and mineral plant food and providing some protection from erosion.

Specific mechanical conservation measures must also be provided such as storm drains, terraces, bunds and silt pits; on steeply sloping lands bench terracing is usually essential. Combined with these must be provision of protective vegetational covers either as planted cover crops or the selective weeding of natural vegetation. Formerly clean weeding was the general rule on tea and rubber plantations in the Far East; much damage ensued, which has only of comparatively late years been checked by the use of more rational methods. Protective covers serve the double purpose of checking erosion and helping to maintain the soil organic matter.

In establishing permanent crops on sloping land, moreover, higher parts of slopes should be avoided, since the conditions are markedly eluvial; they are better left under the natural forest cover to provide additional protection against erosion. The natural acidity of the soils also affects the choice of crops grown, as their tolerance of acidity varies; tea and oil palms, for example, are much more tolerant of acid conditions than is cocoa.

The surface-layer of newly cleared forest land is usually sufficiently rich to enable the establishment of permanent crops without manure. With many crops, sustained yields at a low level can be maintained for long periods without manure, depending on the demands of the crop itself and on the nature of the parent rock from which the soil is derived. Hardy[9] has pointed out that in Trinidad the longevity of cocoa can be greatly influenced by this fact. As cropping proceeds the benefit from appropriate manurial applications increases. When permanent crops are removed as a prelude to replanting it is often necessary to manure before the new stand can be established. Haines[10] has stated, in relation to rubber in Malaya, that the deterioration in this regard can be diagnosed simply as nitrogen deficiency, whilst phosphate deficiency is also often a factor.

Annual crops

The cultivation of annual crops is severely restricted owing to conditions; shifting cultivation is extensively practised on small-holdings by native cultivators, the chenas of Ceylon and the ladangs of Malaya and Sumatra being examples. If the interval between successive cultivations is long enough, and particularly when only small trees and undergrowth are removed, natural regeneration can restore fertility, but if it is unduly shortened, or the attempt made to grow annual crops continuously without heavy manuring, the land deteriorates rapidly and is usually abandoned after a few years. The situation may be worsened by the invasion of cleared areas by the grass lallang (*Imperata cylindrica*) which, particularly because of its liability to be fired during dry spells, prevents the re-establishment of the natural vegetational succession. This has occurred over large tracts in Malaya as a sequel to attempts to cultivate cassava and pineapples as a main crop, and also in parts of Sierra Leone following the continuous cultivation of upland rice.

Cases exist of lands cleared for annual crops and kept clean weeded becoming unproductive. J. Lambourne[11] records that at the Serdang Experimental Station in Malaya a quartzite-clay soil reclaimed from jungle and drained, after continuous cultivation under cassava with clean weeding for five years, would not grow maize, tobacco and similar short-term crops at all. When, however, dressings of pen manure or organic materials in the form of dried grass were given, normal growth was resumed, but artificials alone gave no response (see Figs. 1, 2 and 3). Possibly readily attackable organic matter had been so reduced that it did not suffice to provide energy for the normal biological soil processes; incidentally, the soil contained much free carbon. By contrast in sub-humid climates continuous clean weeding does not show this effect and may be productive of benefit. Presumably the humid conditions account for the difference.

Chinese market gardeners in Malaya convert infertile mining tailings into fertile soil by the liberal use of organic material, including cut grass, sweet potato vines, pig manure and household refuse. Birkinshaw[12] also showed that it is possible by the use of organic material to recondition lands on which slimes from tin dredging had been spread to a depth of several feet.

It seems that under super-humid conditions organic matter can play an important part in maintaining soil fertility. Opinion is divided on the general role of organic matter in tropical soils, and the super-humid tropics may provide a key to the problem, since there the check or reversal of natural processes due to the long dry seasons of the sub-humid tropics is lacking.

Within limits, uses other than for orchard crops can be developed on upland soils. Intercalary food and cash crops are often grown between the rows of orchard crops during the early stages of development, taking advantage of the transient fertility and enabling some cash return to be obtained without impairing greatly the growth of the main crop. In this way many thousands of acres were established in rubber by Chinese planters, the crops grown including cassava, pineapples and gambier.

Market gardening for the production of vegetables can also be successfully practised; ample supplies of organic manures are needed which may have to be supplemented by artificials, and on sloping lands bench terracing is essential. It can be successfully combined with dairying, poultry-keeping and pig-raising. Costs are usually high and readily accessible markets capable of paying remunerative prices are essential.

The scope for animal husbandry is restricted; grazing is largely precluded owing to the high cost of establishing pastures, which will not in any case stand up to more than very light grazing, and the only practicable possibility is stall feeding on cut fodder and purchased foodstuffs on the soiling system. Dairying on these lines has been developed to a limited extent in many countries, *e.g.* in Java, Malaya and Ceylon. Supplies of green fodder are often difficult and many tall-growing fodder grasses grow well, *e.g.* Guinea Grass (*Panicum maximum*) and Napier fodder (*Penisetum purpureum*), but with successive cuttings yields fall off unless they are manured. In many countries animal disease is also a difficulty, particularly tsetse-borne trypanosomiasis. Attempts to overcome this by keeping animals in fly-proof byres have met with some success in Nigeria and the Gold Coast. Costs are necessarily high, and animal husbandry to be successful depends on available markets, although possibilities exist for its combination with the cultivation of permanent crops on a limited scale primarily for domestic use but also for sale.

Wet rice is extensively grown on lower colluvial slopes in Eastern countries. The land is terraced and the crop planted in small bunded compartments, the soil being puddled to retain water on the land. The method favours accumulation of material from the upper slopes and leaching is largely prevented, thereby no doubt helping to conserve fertility.

Land-use on alluvial lands

Taken as a whole the low-lying alluvial lands of the super-humid tropics have a much more extended range of uses. Their

Fig. 4—*Young rubber on sloping land in Johore, Malaya, showing varying growth with fertility gradient on slope*

character varies enormously and they frequently require considerable expenditure of money and effort before they can be used for cultivation, but they are often of relatively high fertility and allow of the permanent cultivation of a wide range of annual crops as well as many of the orchard crops which can also be grown on the uplands.

On this account their potential value for the production of food crops is great, in particular conditions pre-eminently suited for wet rice. The alluvial flood plains of the great rivers and the coastal flats of the Eastern tropics bear the rice crops upon which their dense populations depend, and there is little doubt that opening up of the vast undeveloped tracts of similar lands in other parts of the wet tropics could make important additions to the world's supplies of food.

Rice and sugar

Wet rice is mainly grown by peasant cultivators on small-holdings using hand labour or primitive implements; its cultivation is laborious, exacting and unpleasant. The extension of the cultivation is bound to be slow by these means and mechanisation is the obvious alternative. Mechanical cultivation of rice has been developed in Carolina and Louisiana in the southern U.S.A., in Australia and to some extent in the Piedmont plan of northern Italy, but its adoption in the wet tropics presents problems some of which are not yet completely solved, although efforts to do so are in progress in a number of countries and the possibilities are under examination in others.

An essential need is complete and effective control over the water supply, including protection from flooding and the means for keeping water on the land for so long as it is needed for the growth of the crop and of removing it efficiently and quickly at the ripening stage and in preparation for the harvest. Drainage takes precedence over irrigation and frequently good crops of wet rice can be grown on rainfall alone provided the water is kept on the land. Irrigation is of value to make good seasonal variations in the rainfall, and commonly conditions permit of the development of irrigation projects.*

Other annual food crops can also be grown on lands of this type provided they are drained, such as dry grains including maize, a variety of pulses, some root crops and green vegetables. Where drainage is effectively controlled, wet rice can be grown in alternation with dry crops in succeeding periods. In the Preanger plain in West Java it is common to see rice in all stages of growth and on adjoining lands crops of dry grains or green vegetables. In parts of Malaya green vegetable crops are often grown between two crops of rice.

A number of cash crops can also be grown; sugar cane is well suited to such conditions provided drainage is adequate and the manurial requirements met. In British and Dutch Guiana the major part of the cultivated coastal alluvial lands are devoted to growing sugar cane and rice. In West Java in former years sugar cane, rice and pulses were combined into a standard rotation, and there seems no *prima facie* agricultural reason why such rotations should not be adopted under similar conditions elsewhere.

**In some countries two or even three crops of rice are grown on the same land every year, using short-term varieties of the crop.*

Perennial crops

The perennial crops also do well; rubber, coffee, oil palms and even tea and cocoa thrive provided drainage is adequate and the soil acidity is suited to the needs of the crops. Coconuts, although they are for the most part grown on sandy soils with a moving water table not far below the surface, are extensively grown on coastal alluvial clay lands on the western side of the Malay Peninsula when the lands are properly drained.

In view of their potential value for the cultivation of food crops it seems doubtfully wise policy to encourage the growth of permanent crops for export on lands of this type unless the foreseeable requirements for food supplies are adequately provided for. In Malaya, for example, many thousands of acres of good potential rice land were alienated for rubber cultivation. The Malayan Rice Cultivation Committee of 1931 recommended that, in view of the probable future requirements for rice of the growing population, no similar alienations should in future be made.

Once they have been reclaimed and drained, heavy alluvial lands often exhibit considerable reserves of fertility; for example, coconuts growing on such lands in Malaya gave no response to varying combinations of manurial applications. No doubt, in due time, after prolonged cultivation, deficiencies would make themselves felt, but available evidence appears to point to such lands being cultivable for long periods in this crop before plant food deficiencies show themselves. Numerous examples also exist of such lands continuing to give satisfactory rice crops for long periods without manure.

In British Guiana, coastal alluvial lands which, after long cultivation in sugar cane, are deteriorating notwithstanding that they are manured regularly with sulphate of ammonia, benefit considerably from flood fallowing, *i.e.* submergence under water for periods of from 6 to 12 months or more. Similar beneficial results have been found to follow the practice on banana lands in Central America which had deteriorated badly from Panama disease. The reason for the improvement is not entirely clear, but the benefit is undoubted.

It seems possible that the regular submergence of the soil which is essential in the cultivation of wet rice may be equally beneficial, in which case the alternation of wet rice with dry crops may be an effective system of land use.

Peat soils

As has been mentioned, the occurrence of tracts of peat of varying depth is not infrequent and their utilisation presents a

special problem. They are very acid and in an undrained condition are of little value; when they are drained they become fluffy and the organic matter disappears very rapidly with great shrinkage in volume. They can be used for certain crops; coffee does fairly well on the pegasse soils of British Guiana and also on the peat soils of Malaya, and recently there has been some development of pineapple cultivation on them in the latter country, whilst coconuts and oil palms have also been grown on them. They grow fairly well in the early stages, but later as the peat layer disappears the trees often lean badly and have to be propped, which is a disadvantage.

The alluvial lowlands offer greater scope for animal husbandry than the uplands, although the wet nature of the ground and liability to flooding limit the possibility of grazing, and livestock diseases are a difficulty. For large-scale grazing drainage is essential, but expensive drainage schemes for grazing alone are doubtfully economic. A period of resting under grass might be a useful component in a rotation for rice lands; in some tropical countries cattle actually are grazed on rice lands between crops, whilst two or three years under grass forms part of the rotation on rice lands in northern Italy, although conditions there are not comparable with those in the tropics.

Under very wet conditions water buffaloes have advantages over cattle and may offer somewhat greater resistance to some of the maladies.

On the whole, however, the stall feeding of livestock on the spoiling system probably holds out the greatest prospects of success; supplies of green fodder are more easily provided, and the cultivation of grains and pulses facilitates the provision of concentrates; the waste products of rice milling can supply quantities of concentrated stock food, whilst oil mills for the treatment of copra, for example, can give supplies of press cake.

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Record-Breaking Dairy Show

THE 63rd annual show of the British Dairy Farmers' Association is an event of national and, in fact, of international importance. As on previous occasions, it was held at Olympia between October 25 and October 28, and during the four days of the show 102,097 persons attended, constituting an all-time record. Visitors included dairy farmers, stock breeders and technical and trade representatives, not only from the United Kingdom, but also from many overseas countries, including most countries of Europe, the U.S.A. and the various parts of the British Commonwealth.

Limitations of space restricted the number of livestock exhibits, since not many more than 700 cows and heifers can be shown adequately if room is to be found for the numerous trade exhibits on which the show largely depends for support.

Under the existing qualifying rules all cattle admitted for exhibition must have produced in a lactation period at least the quantity of milk with the specified percentage of fat required by the rules, but with the growing excellence of British dairy breeds it seems not unlikely that the qualifying requirements may have to be raised in future years if the number of exhibits is to be kept within the limits imposed by the conditions.

This year the feature of the exhibition on the livestock side was the challenge made by the Ayrshire breed for supremacy in the competitions; this was unsuccessful, however, and the British Friesian team of six cows won first place and the Bledisloe trophy on the combined points of milking records and inspection in the ring, the second place going to the Jersey Society, leaving third to the Ayrshires, although on milk yields alone they were runners-up for the first place.

The Buckhurst trophy, awarded for consistent milk production over three successive lactations, was won by the Jersey Society.

More than 2,400 exhibits appeared in the poultry classes, while those for goats, pigeons and rabbits were also well represented.

The 480-odd stands of trade exhibits showed all aspects of dairying and dairy appliances—machinery used in the industry and fittings for cow byres and milk rooms. The Ministry of Agriculture, the Milk Marketing Board and the Iodine Educational Bureau staged technical exhibits, the exhibit of the Ministry including a demonstration of the production of tuberculin, while that of the Milk Marketing Board laid special stress on equipment suited to the needs of the small dairy farmer.

An exhibit which attracted special attention was that of the Opperman grass and grain drier, which was demonstrated during the show.

Indonesia Struggles to Restore Its Sugar Industry

J. GRINDROD, B.A. (Com.)

Until the war the sugar industry of Java was among the most efficient and progressive in the world. Its achievements were world famous, and the research work of the celebrated experimental station at Pasoeroan paved the way for improvements in most other cane sugar-producing countries. Since the war the industry has suffered double disaster, firstly at the hands of the Japanese invaders and secondly at the hands of the insurgents during the fighting which followed the liberation. The physical and economic harm caused by this strife is now being slowly repaired by the industry, and today, in spite of uncertainties still, attempts are being made to raise sugar production to at least pre-war levels within the next four to five years.

SUGAR holds rather an unusual place in the Indonesian economy. Essentially a Western crop, it is grown in rotation with rice which is essentially Eastern. It also has a special sociological importance inasmuch as it is cultivated very intensively and has been closely interwoven into the economy of the most densely peopled regions of Java. Populations of from 300 to 500 persons per sq. km. are quite normal in the sugar-producing areas, and in certain districts where before the war Mr. Meyer Ranneft conducted investigations into the people's income, it was found that rather more than 20% of it comprised wages earned on the sugar estates.

Labour requirements

Although the labour requirements of a sugar estate vary greatly throughout the year, an average size estate will normally employ about 1,100 persons, but during the campaign months from May to September this figure will increase to 2,400. In spite of the dense population of Java there are periods in which the estates are actually hard put to it to provide the full quota of workers. This is especially so when the seasonal requirement of the sugar crop coincides with the heavy demand for labour made by native food cultivation.

Of the permanent personnel 30% consists of native foremen who are important links between the Western and Eastern peoples in the industry.

In two ways, therefore, the fortunes of the native population are closely bound up with the prosperity of the sugar industry in Indonesia. In the first place, native rice cultivation benefits greatly from the rich manure residues left in the soil after the sugar crop, and in the second place a large part of the native population depend for their living upon income derived from the sugar industry, not only as wages but in the form of ground rents and other revenue.

Hand-cutting and transport of sugar cane on a typical plantation in Java. Labour requirements of a plantation rises considerably during the campaign months of May-September and in spite of the dense population labour is often short. Reason is that this seasonal demand coincides with the heavy requirements of labour made by native food cultivation

Production

Sugar production is almost entirely in the hands of large companies and is centred on Java. Even before the war Indonesian sugar suffered severe set-backs, as the following table shows:

WORLD PRODUCTION OF SUGAR (in metric tons)

Year	*World production (cane and beet)*	*Java production (cane)*	*% Java crop of sugar cane*	*% Total*
1926-27	23,758,000	2,399,907	15	10.1
1927-28	25,319,000	2,989,863	18.4	11.8
1931-32	26,799,000	2,611,376	14.4	9.7
1932-33	24,476,000	1,401,327	8.4	5.7
1933-34	26,014,000	644,164	3.8	2.5
1935-36	29,124,000	592,390	3.2	2.0
1936-37	31,437,000	1,414,500	6.6	4.5

This serious recession in sugar production was largely a result of the general depression of the 1930s. Before the 1914-18 war world production of cane and beet sugar were about equal, but after that

war the ratio came to be about 4 and 1. The Java sugar cane industry had by that time so improved its methods that the cost of production was very low indeed. The yield per acre had increased from 3.4 metric tons to 4 metric tons, yet, in spite of this, markets were lost, especially in India, which in those years commenced to protect her own sugar industry. As a result stocks of sugar in Java and Madura rose from 7,000 metric tons in 1928 to as much as 2,553,000 metric tons in 1933.

In 1931 payments to natives by way of wages, ground rents, etc., amounted to fls. 111 million as against only fls. 11 million in 1935 and fls. 10,944,000 in 1936. The purchasing power of the native, as well of the estate companies, was thus very much reduced, and this is reflected in considerably reduced imports into Java during these years.

Effects of the war

The position improved considerably from 1937 to 1940 when the threat of war was becoming imminent, but the outbreak of war and the Japanese occupation in 1942 brought disaster to the industry. To the war damage caused during the Japanese occupation must be added the serious effects of the scorched earth policy of the Republicans during the civil disorders which followed.

Actual war damage sustained by the sugar estates is estimated at fls. 210 million, 1941 value; to this must be added loss of stocks and profits as well as the damage caused by the insurgents, and the total damage caused in Federal Indonesia is estimated at about 50% of the gross capital value of the industry.

This extensive damage and the still uncertain prospects of settled conditions in Indonesia, together with the risks that attend world marketing of this essentially export crop, have set the Indonesian estates a difficult problem.

Rehabilitation

Large sums of capital are required for the rehabilitation of the industry, especially for factory equipment. A modern Indonesian factory of medium size cost about fls. 5 million before the war. It would cost three times as much now, even assuming that the installation of new plant was possible. The working capital required for planting and milling an area of 1,000 hectares before the war was not less than fls. 700,000, and this figure also can be multiplied by three under present conditions. Moreover, sugar is a seasonal crop which cannot produce revenue immediately. On this account increased rates of interest are demanded by investors, who also expect reasonable guarantees of freedom from civil disturbances that would disrupt activities and from abnormal risks in regard to labour supply, acquisition of the necessary land, provision of irrigation water, etc.

Uncertainties regarding the future political structure of Indonesia have led to uncertainties about the legal and industrial security of sugar enterprises and also the form and type of the civil authority under which they would be compelled to operate. This was particularly the case in the Sidoardjo Delta before the signing of the agreement of Linggadjati and some uncertainty continued to prevail even after the agreement had been signed.

Government action

Because the sugar industry was so important as a source of native earnings and in providing foreign exchange, the Government eventually guaranteed the industry against the possible loss of invested capital for the year 1947.

Nevertheless, many investors had difficulty in finding sufficient finance, since the loss of capital for a full harvest year had already been incurred when the Japanese invaded Indonesia in 1942. It is true that some production was maintained during the occupation and that sugar stocks at the time of the Japanese capitulation were greater than at the time of the invasion, but much of these were subsequently lost through the action of the Republicans and certain of the Indonesian estate managers. In addition, large quantities were clandestinely removed from Java. According to official Republican records at the time of the capitulation, 157,000 tons of sugar were lying on the north coast between Cheribon and Samarang, but eventually only about 7,000 tons of this was recovered, resulting in a loss of working capital of fls. 75 million.

The assignment by the Government of foreign exchange for reconstruction purposes was also a matter of difficulty, since the sugar industry did not fall easily into the main categories to which priority in exchange was given.

Local difficulties

In addition, many local difficulties arose in the sugar-producing districts. For example, in the fertile Sidoardjo Delta, where sugar has always flourished, many problems had to be faced. The destruction of some of the irrigation works in the neighbourhood of Lengkong by the Republicans inundated the Sawah area and delayed the ripening of the rice crop; in consequence the land did not become available for sugar planting until it was too late. Moreover, large numbers of people were removed by the Republican forces and this led to shortage of labour, particularly of factory hands, who were urgently required for reconditioning and maintenance of installations. In addition, the natives were physically in a poor way through under-nourishment; rice had gone up in price from fls. 0.06 per kg. before the war to fls. 1.28 per kg.—*i.e.* about 20 times.

Although some sugar cane planting had been collected in the neighbourhood of Ketegan, there was not enough to go round, while the quality was poor, little attention having been paid to its selection.

To encourage labour, wages were paid in Netherlands Indies currency, for which the worker could obtain badly needed clothing and textiles from the estate shop —also lamp oil, salt, coconut oil and soap.

In the north coast district, including Cheribon, the Republican scorched earth policy had added to the Japanese damage to installations as well as having wasted huge quantities of sugar through incendiarism and extravagance. The electrical installations on the estates suffered especially, all copper fittings being removed. Estate houses were destroyed and the offices of the factories around Tegal, Pekalongan and Pemalang were burnt down and records destroyed. Irrigation, also, was seriously neglected.

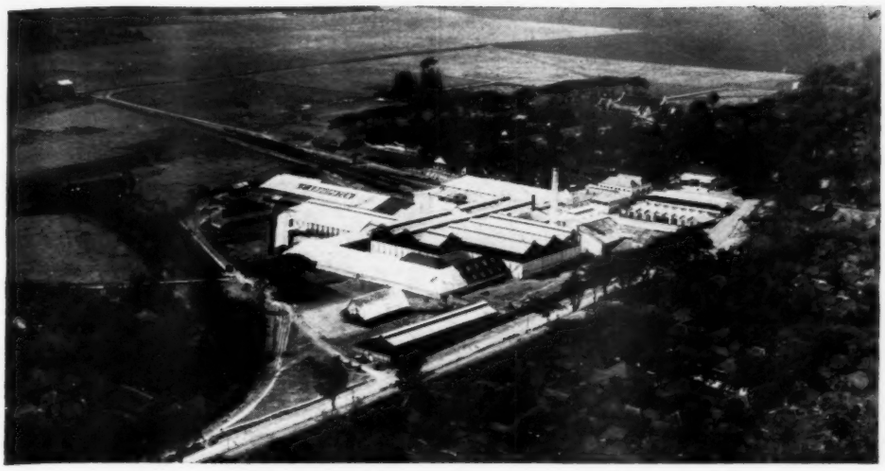
In East Java, too, much damage had occurred, *e.g.* on the Kebonagoeng estate, which is close to the demarcation line, and in Loemadjang and Djember where the modern factories of the H.V.A. are situated. The Bedagoeng factory was also wrecked by the Japanese, while the fourth largest sugar factory in the world, namely Djatiroto 1, was rendered unfit for the manufacture of sugar. However, there still remained in an operable condition in this area the factories of Djatiroto 2, Semboro and Goenoengsari with a joint capacity of 80,000 tons, which gave about 35% of production in the East Java sector.

Post-war production

The following figures give the sugar production, in metric tons, during the war and post-war years:

Year	
1938	1,375,000
1939	1,562,500
1940	1,587,400
1941	1,702,000
1942	1,340,000
1943	683,000
1944	497,000
1945	28,000
1946	Nil
1947	7,400*
Jan./Oct., 1948 (prov.) ..	43,000*

**In federal territories*



Aerial view of one of the numerous sugar factories in Java

Production in 1947 was very small. In 1948 it was stated that of the 63 existing factories in the area under Dutch control 22 were fit for work, 14 still had to be repaired and 27 were considered as being completely unusable. Plantings in 1948 to be processed by about 25 factories during 1949 totalled 25,000 hectares, which would yield a possible production of 250,000 tons of sugar.

During 1948 total sugar exports amounted to 63,000 tons, value at fls. 23.4 million. The chief markets were:

	Million fls.
Singapore	6.3
Netherlands	4.4
Japan	3.9
Siam	2.1
Hong Kong	2.2
Ceylon	1.4
England	1.3

Little is known about sugar production in the Republican territories, but plans were stated to exist for planting cane on a large scale in 1948.

Future outlook

The target which Federal Indonesia has set for sugar production over the next four or five years involves the raising of production to such a level as will provide export surpluses at about the pre-war figure, in addition to providing requirements for local consumption. The actual planned exportable quantities in 1952-53 depend upon the demand at that time prevailing in the world markets and, in some cases, production is expected to be lower than pre-war. Provisional targets for 1952-53 have been set at the maximum physical potential, which for sugar is put at 1,100,000 metric tons.

The sale of Java sugar before the war was confined almost exclusively to the 'free markets' of the world, that is to say, those where it did not have to compete with sugar receiving preferential treatment. The war-time and post-war shortage of sugar due to damage in Europe and in the Pacific region (Java, the Philippines, Formosa) was almost all made good within a period of three years; rapid recovery has occurred in the European beet sugar industry, while Cuba has had exceptionally large harvests (1947: 5.9 million tons, as against 3 million tons in 1940).

Thus, during the time that Indonesia has been troubled with internal strife, the world sugar situation has improved to such a degree that Java has missed the benefits of a seller's market and the high prices obtainable therein.

Nevertheless, shortages seem likely to prevail in the Near East and Far East for some time to come, and there appears to be some prospect that Java may be able to resume at any rate her old role of major sugar producer for these regions.

Sugar research

One of the most severe blows suffered by the sugar industry as a result of the war and the subsequent disturbances has been the extensive damage sustained by the Experimental Station for the Java Sugar Industry at Pasoeroan in East Java. This institution, which played a part of the utmost importance in making the Java sugar industry one of the most progressive and efficient in the world, was severely damaged both by the Japanese and subsequently by the Republicans. Buildings were wrecked or destroyed and much of the equipment and, even more serious, most of the documents and records have been irretrievably lost. However, reconstruction is being carried out actively and various aspects of the research work restarted. The rehabilitation of this scientific work is of vital moment to the industry, since without it full success in the revival of the industry cannot be achieved.

Developments in West Punjab

WITH the establishment of Pakistan on August 14, 1947, the former provinces of the Punjab were divided into two new provinces, West Punjab and East Punjab. The former, comprising an area of 62,012 square miles, was included in Pakistan.

Among the first important steps taken to put the progress of West Punjab on a sound basis was a penal law enacted to save the province from the danger of losing foreign markets for its cotton.

Special attention has been paid to a scheme of irrigating and colonising a wide expanse of desert, known as Thal, in the north-west of the province, which is by far the most important scheme of economic development that the province has in hand. Afforestation and agriculture will, it is expected, completely change the present forbidding aspects of this area.

New irrigation board

In order to overcome the initial difficulties, a Board has now been created on the lines of the historic Tennessee Valley Authority in America. The Board will not only deal with land already owned by the Government, but also acquire privately-owned areas for purpose of systematic colonisation. A small part of the Thal area has already been colonised by the families of the Muhajireen personnel in the Pakistan Army. They have already reaped a bumper crop of wheat and gram from their virgin lands.

Another of the basic problems of West Punjab is that of arresting the deterioration of land through water-logging in canal-irrigated areas. The remedial measures, never quite adequate, that were being taken before partition could not be fully maintained during the subsequent years. They are now being reorganised in the light of the present needs and conditions of the province. Similarly, steps have been taken to give fresh impetus to departmental work in connection with long-term schemes of developing and expanding West Punjab's scanty forest wealth, improving the number and breeds of its cattle, developing its supply of electric energy and expanding its industries and other basic factors of economic prosperity. The proposed hydro-electric power plants will make this province independent of East Punjab and will provide a network of grid stations which will supply energy everywhere at economic rates.

Menace of the Red Locust

In our November issue an article appeared on Locust Destruction in South Africa, and in it mention was made of the serious situation in Central Africa in regard to the Red Locust—Nomadicris septemfasciata. The information given below, taken from a recent article in "The Times," supplements that previously given and discusses and describes the outstanding features of the situation.

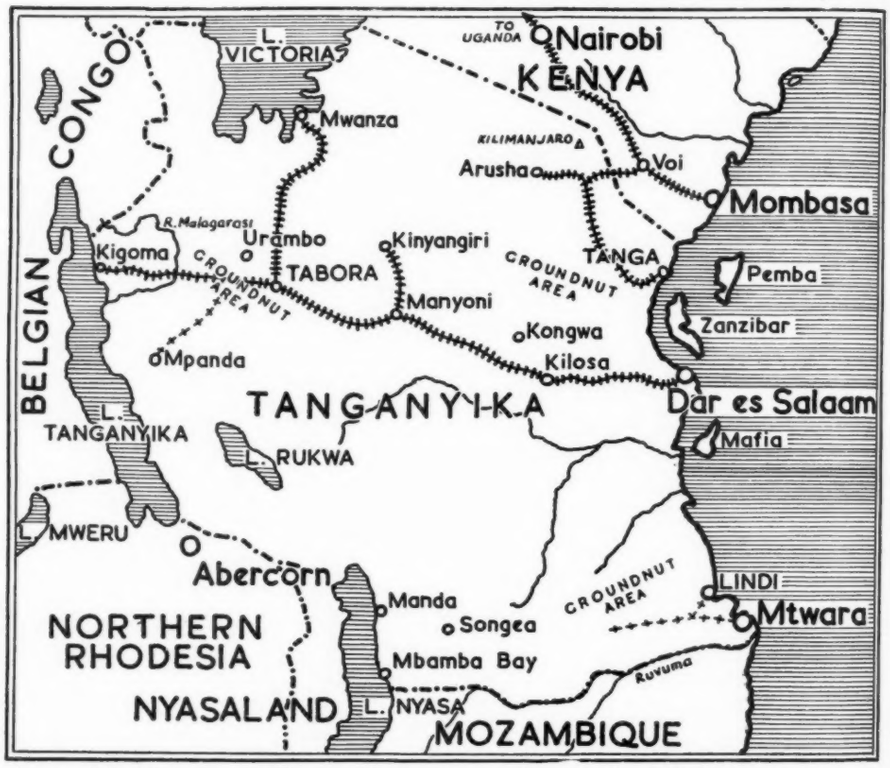
A DRAFT international convention for the control of the red locust was first studied at a conference at Lusaka, Northern Rhodesia, in 1945, and after amendment was accepted in 1947 by all participating Governments. It now forms the clear-cut formal basis of the organisation. Contributing Governments are those of Kenya, Uganda, Tanganyika, Northern Rhodesia, Nyasaland, the High Commission Territories (Bechuanaland, Basutoland and Swaziland), Southern Rhodesia, Belgian Congo, Ruanda Urundi and South Africa. The scale of contributions is indicated by the 1948-49 figures, when South Africa provided £25,749, the Congo £22,071, Southern Rhodesia £11,036, Tanganyika £10,571, and the other territories smaller amounts.

Air campaign

On the practical side, four years of intense activity began during the 1944-45 breeding season, when the situation at Rukwa and Mweru was found to be so bad that migrating swarms threatened to spread over all eastern Africa from Natal to Uganda. An energetic ground and air campaign was organised and £158,000 was voted for the following year's campaigns in the known outbreak centres, in addition to £25,695 for recurrent expenditure. On this occasion all locust concentrations discovered were destroyed before migration occurred.

The position was again threatening in June 1947, when known outbreak centres were being 'reinvaded.' A £57,000 campaign against 'hoppers' was launched and an air campaign against adults later in the year. At a conference in Pretoria in December it was decided to double the air campaign at a cost of £50,000.

In spite of extensive use of aircraft, the bulk of the scouting and control work in these roadless, unmapped swamps and plains was done by trained Europeans and Africans walking through the affected areas on a systematic plan and recording the numbers of 'hoppers' or adults encountered for each 100 steps. Thus, a strict numerical estimate of any increase can be made even when the numbers of locusts are at a minimum and long before anything can be observed from the air. By the time 'gregarisation' is well established immediate danger to distant territories already exists. The most effective means of destroying the locusts on the ground has proved to be dusting with insecticide from a special vehicle, when upwards of 90% mortality has been attained.



A map of the locust area. The groundnut areas mentioned in the Editorial on page 139 are clearly marked

Saving in control costs

The success of these campaigns proved that a high measure of control over actual outbreaks was possible, although at great expense, but, as described above, this success later led to substantial economies. For example, money voted for a campaign in the Rukwa for 1948-49 was not needed and labour engaged for that purpose was used for roadmaking in the area. Extensive control work was, however, carried out at Mweru last season and some concentrations were destroyed in the Malagarasi—an area where a particularly careful watch is being maintained at the present time.

Research programme

A comprehensive research programme has been initiated to discover why Lake Rukwa in Tanganyika and Lake Mweru wa Ntipa in Northern Rhodesia are outbreak centres of *Nomadacris septemfasciata* (the red locust); and to try to make some fundamental change in the environment which will permanently prevent locusts from swarming. All other similar swamp areas will also be explored. Until this knowledge is obtained it cannot be said that the complete control of the red locust has been fully achieved, but the inauguration of the new laboratories and headquarters of the International Red Locust Control Service, which took place at Abercorn, Northern Rhodesia, recently gives good grounds for believing confidently that it will be attained in due course.

THE SOIL AND THE FRUIT TREE

Amos Memorial Lecture at East Malling

ON October 18 Mr. B. S. Furneaux delivered the second of the series of Amos memorial lectures at the East Malling Research Station on the subject of the soil and the fruit tree, Dr. F. R. Tubbs, Director of the Station, presiding.

In the course of his remarks Mr. Furneaux pointed out that one of the great obstacles to progress in the study of the effect of the soil upon the fruit tree is that the root, which is so much greater than the part above ground, lies inaccessible and invisible, in an environment which we find hard to picture. Besides the food which we are accustomed to supply as fertilisers, the plant roots require air and water even more urgently. It is upon its capacity to offer these that the quality of a soil largely depends.

Soil types

Soils occur in varieties almost as diverse as the plants that grow upon them. A system for recognising and naming each individual series is now almost universally used; all soils that are alike in the following five characteristics (1) the geological origin of their mineral matter, (2) the manner in which this has been converted into soil, (3) the natural drainage, (4) the topographical position and (5) the soil profile, are placed in the same soil series and given the same name. By mapping the distribution of the individual soils in orchard land and fruit plantations, and by observing the performance of the crops on each, as has been done in the Fruit Soil Surveys in Kent, it has been found possible to build up a wealth of data as to the fruit-growing value of many soil series.

By comparing the records of many such soil series, certain generalisations have emerged which make it possible to look at an unfamiliar soil and make an assessment on the spot of its potentialities for fruit growing. A careful examination is necessary for the depth of the soil, taking into account the nature of the mother 'rock' lying beneath. The natural drainage, moisture retention and supply of water can be determined from evidence in the soil itself, while the texture and structure must also come into consideration. A comparison of what the soil has to offer, with our knowledge of the requirements of the various fruit crops, makes it possible to place each where it may have a reasonable chance of success. The soil may not offer ideal conditions for each kind of fruit which it is desired to grow; most fruit crops, however, show a range of tolerance, some far greater than others, and by taking advantage of this it is usually possible to work out a sound planting plan.

Fruit trees and the soil

Cherries are the most exacting in their requirements. They must have a well-drained, medium-textured soil, and if they are to do really well the soil must be deep. Dessert apples also must have good drainage, but they are more accommodating as to soil texture and depth, doing well on all manner of soils, from the light sands of Suffolk to the heavy clays of the Sussex Weald, wherever the necessary 18 to 24 in. depth of soil can be found. Culinary apples do best on the deeper soils but will tolerate much poorer drainage than dessert varieties. Pears will put up with quite poor drainage and are particularly successful on heavy land, flourishing even on shallow clay soils such as are frequently found on the London clay. Plums resemble culinary apples in their requirements. Gooseberries, especially the variety Leveller, demand a well-drained deep soil though Careless is less particular in this respect. Blackcurrants prefer the medium and lighter types of soil. They will tolerate poor drainage better than any other fruit. Raspberries are similar to gooseberries in their needs. Loganberries and blackberries succeed on many soils, but to avoid winter frost damage to canes, the soil selected should not encourage autumn growth. Strawberries do best on deep moisture-holding soils and can withstand a considerable degree of poor drainage.

Soil biology

But the soil is not a dead, inert raw material. It is a most complex association of materials and forms of life, which is dependent for the results it gives, upon the management to which it is subjected. Even the best soil may be farmed right out or the worst made to crop tolerably well. A proper examination of the soil in the field will solve many problems of cultivation and drainage, and make the realisation of its full potentialities possible. Many a failure can thus be avoided and much time and money saved. The practical grower and the research worker cannot afford not to know intimately the soils with which they work, even though this branch of science is only, as yet, in its early days of development.

Before the meeting dispersed Mr. Furnaux dealt with a variety of written questions from the audience covering almost every aspect of his lecture.

Laboratory demonstrations

Prior to the lecture arrangements had been made for visitors to inspect the work in progress on the field plots of the station, but this arrangement had to be cancelled owing to inclement weather. Instead, a

Mr. H. M. Tydeman lecturing on apple and blackcurrant breeding in one of the greenhouses during the demonstration

series of demonstrations was given in the laboratories and the greenhouses, of which a brief account is appended.

Mr. H. M. Tydeman gave a brief history of breeding work on the blackcurrant Wellington XXX and of attempts to produce better cropping varieties by treating seedlings with colchicine to make them into ' tetraploids.'

Phosphorus insecticide

Dr. G. H. L. Dicker discussed experience of some of the new phosphorus insecticides, H.E.T.P., T.E.P.P., Parathion and Pestox III. The first two could be regarded as possible substitutes for nicotine in that they left no residual effect. Parathion was probably more valuable as it had some residual effect and appeared to be effective against red spider and aphides. Pestox III has some degree of systemic action. He regarded all these materials as still under experiment and growers should go cautiously.

Grafting

Mr. R. J. Garner gave a talk on some uses of grafting on the fruit farm. He showed how incompatibility in pears could be overcome by double-working, how plum trees resistant to bacterial canker could be built up, and how injuries could be repaired by bridge-grafting and in-arching.

Mr. A. C. Painter called attention to the importance of grading fruit, a lesson which the markets this year had forcibly demonstrated.

Mr. A. P. Preston had arranged an exhibit dealing with various aspects, ranging from pruning and new rootstocks to meteorological recording.

Transfers and Promotions in the Colonial Agricultural Service

P. C. CHAMBERS,
Senior Agricultural Officer, Kenya.
Director of Agriculture, Cyprus.

R. G. HEATH,
Senior Agricultural Officer, Federation of Malaya.
Chief Field Officer, Federation of Malaya.

W. J. M. IRVING,
Senior Agricultural Officer, Uganda.
Assistant Director of Agriculture, Uganda.

J. C. MUIR,
Director of Agriculture, Tanganyika.
Member for Agriculture and Natural Resources, Tanganyika.

C. C. SKEETE,
Director of Agriculture, Windward Islands.
Director of Agriculture, Barbados.

New Techniques

Proteins and Fats from Yeasts, Algae and Fresh Water Fish

The numerous papers read at the United Nations Conference on the Conservation of Natural Resources left the overwhelming impression that there is little substance, at least on the technical plane, in the melancholy forecasts of the American, William Vogt, and his fellow neo-Malthusians. The world has ample technical means of raising production and living standards to an adequate level, the main obstacles are social and economic. Among the most interesting contributions were two groups describing comparatively simple avenues to a swift rise in the output of proteins and fats, viz.:—The macroculture of yeasts and algae and the pond culture of certain warm water fish.

A PROTEIN-producing yeast of the species *Torulopsis utilis* was grown on a commercial scale in Germany during the war, F. N. Woodward of the Scottish Seaweed Research Association reported, and is being cultivated successfully now on a pilot-plant basis in Jamaica and the U.S.A. The design of processing equipment is currently in flux and food yeast is not yet widely acceptable as an article of human diet. But there is little double, he declared, that *T. utilis* can be produced economically and that palatable strains will be found. Ample supplies of carbohydrate waste—the substrate on which the yeast grows—can be obtained from sulphite pulp mill liquor, waste wood, agricultural wastes or seaweed. Another variety of yeast, *Rhodotorula gracilis*, described by Harry Lundin of the Royal Institute of Technology, Stockholm, is as easily grown in a waste carbohydrate medium and can be made to yield 30 lb. of edible fat similar to palm oil per 100 lb. of substrate, in a growing cycle of 60 hours.

Strains of the algal genus *Chlorella*, which has become familiar as a result of its usefulness in photosynthesis studies, are also a potential source of edible protein and fat. They would have the advantage, Dr. Woodward said, of not requiring an organic substrate, as they manufacture their own carbohydrate.

In another paper, Ernest David Bergmann of the Israeli Weizmann Institute of Science, pointed out that no less than 24 products of major importance to the food, pharmaceutical and chemical industries can be obtained in quantity by microbial fermentation, and that several produce valuable animal feeds as by-products. A.P.F. (animal protein factor) livestock feed supplement, for example, is a by-product of the fermentation processes utilised in manufacturing the new antibiotic drug aureomycin and the B-vitamin riboflavin.

Cultivation of fresh water fish

Of even greater immediate value is intensive cultivation of food fish in waste farmland ponds. Developed in South China about 650 B.C., pond culture is fairly widely employed in South-East Asia and Palestine, but not to a significant degree anywhere else. By systematically applying all types of manure, including night soil, to their ponds—to fertilise the marine plants on which the fish feed—south Chinese peasants obtain as much as 4,000 lb. of fish per acre of pond per year, S. Y. Lin of the Hong Kong Fisheries Research Department reported. In India, Java, Malaya and the Philippines, where night soil is not used, but where treated sewage may supplement other manures, yields range between 450 and 3,500 lb. annually per acre. Even where fish culture is carried on in rice padi during the few months each year the fields are flooded—as in Japan—yields of several hundred pounds per acre per season are obtained.

The species most widely cultivated is the Chinese carp, a relative of the carp once grown in the palace gardens of continental monarchs and still raised in Central European villages, though not in a comparably intensive way. Nearly a score of Asiatic fish species altogether have been ' domesticated '; they include several salt-water varieties raised in salt pools along the coast. ' Fish farming ' demands little capital or skill; it can be carried on with equal effectiveness in a tiny backyard pool dug by the peasant cultivator himself

Increasing Food Supplies

LEONARD ENGEL

and in dammed-up lakes of large size. The principal need for technical skill, declared Sunder Lal Hora, director of the Zoological Survey of India, is in the hatcheries supplying the fry. There is enough marsh and other waste land in South-East Asia to multiply the fish crop by several times, Dr. Hora, who served as rapporteur for a special meeting on fish farming, added, and the technique can be readily extended to Latin America and other protein-hungry tropical areas. (Fish farming is also possible in the temperate zone, but yields are very much smaller.) In case indigenous fish varieties grow too slowly, or do not adapt themselves to domestication, Asiatic species can be transplanted.

Implements for small farmers

Along more conventional lines, the conference heard several reports on implements designed to raise the efficiency of the small farmer. Particular attention was attracted by the National Institute of Agricultural Engineering scheme for utilising a cable and demountable winch to give the inexpensive walking tractor the muscle to pull a plough, and by two implements developed for the Indian peasant at the Allahabad Agricultural Institute. One, a lightweight steel plough to replace the traditional wooden plough, will make it possible for him to plant and turn under green manures. The other, a three-pronged animal-drawn cultivator, can be used as a simple but effective seed drill by fitting it with locally made bamboo tubes and seed funnels fashioned from old cans. The combination of the new plough and cultivator, Mason Vauch of the Allahabad Institute estimated, can improve Indian cultural practices enough to double yields.

Local conditions and improved crop varieties

A point which was emphasised repeatedly was the necessity for care in adapting improved crops and livestock to local conditions. During recent years, for instance, P. V. Cardon of the U.S. Department of Agriculture pointed out, a great many American crop varieties developed from European stock have been re-exported. Many of these, he warned, will not do well in their ' new ' homes without re-acclimatisation.

Improved livestock

The same applies to livestock. Three authors—J. O. Grundstaff of the South-Western Range and Sheep Breeding Laboratory, New Mexico, John Hammond of the Cambridge School of Agriculture, and A. O. Rhoad of the Inter-American Institute of Agricultural Sciences, Costa Rica — recommended that indigenous strains represent three eighths to one half of the stock entering into crosses between indigenous and improved animals. Dr. Hammond further urged the organisation of a co-operative breeding effort, with a large number of centres concentrating on a few selected crosses, to speed fulfilment of the long-felt need for a satisfactory tropical breed of dairy cattle.

Tropical rain forest areas

In approaching the difficult problem of developing tropical rain forest areas, consideration ought to be given to the possibility of mixed farming, two Dutch agricultural scientists with wide experience in Indonesia, E. de Vries and J. van Beukering, declared. Consideration has been given hitherto, they said, mainly to tree crops and wet farming of the traditional Asiatic kind. The applicability of modern mixed farming has never been adequately investigated. It may prove adaptable even to the severe conditions of the rain forest and may make a substantial contribution to the utilisation of idle lands covering 5,000,000 square miles.

Improved farming methods, it was also pointed out, must be adapted not only to local physical conditions but to local social and economic conditions as well. This is particularly urgent, B. A. Keen, director of the East African Agriculture and Forestry Research Organisation, told the conference, in under-developed areas where ancient systems of land ownership and social taboos may lead peasants to refuse to adopt improvements whose value they themselves freely admit. The obstacles presented by the strip and fragmentation land-holding systems can be largely circumvented, however, by devices like the Sudan Plantations Syndicate. The syndicate, which Dr. Keen described in detail, leased 400,000 hectares of fragmented landholdings in the Sudan Gezira from their innumerable owners, laid out the land in accordance with irrigation requirements and then rented it to tenants for growing cotton. Another approach, ' planned group farming,' has been devised in Kenya. In ' planned group farming,' P. C. Chambers of the Kenya Agriculture Department explained, individuals retain ownership of strips, but must use each section of land as directed by vote of all landholders with holdings in the same contour.

On the other side of the coin, new developments of primary interest in technically advanced countries, noteworthy experiments were reported by P. D. Sears of the New Zealand Department of Scientific and Industrial Research, and D. A. Campbell of the New Zealand Soil Conservation and River Control Council. In a ten-year trial, Mr. Sears obtained yields of 9,600 lb. of dry matter per acre per annum from upland pasture, and 14,000 lb. of dry matter per acre per year from lowland pasture on New Zealand's North Island by a combination of mixed planting (clover and grass), intensive treatment with lime and superphosphate and return of dung and urine. These reflect increases of the order of 800% over the yield of natural pasture. As an aid to keeping down costs, tests described by Mr. Campbell have demonstrated the feasibility of dressing pasture with fertiliser by air.

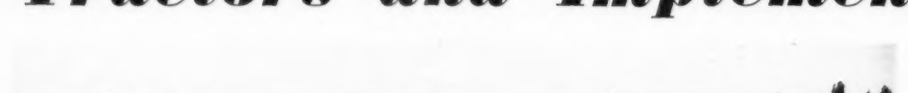
Soil surveys

The necessity of making soil surveys as a basis for effective land use, both in technically advanced countries and in countries which have still to tread the road to the twentieth century, was underscored in separate papers by C. E. Kellogg of the U.S. Department of Agriculture and Sir William Ogg, director of the Rothamsted Experimental Station. To minimise the cost for undeveloped areas with limited financial resources, use of rotating temporary survey parties was urged by G. F. Clay of Rothamsted, who told the conference of such a system worked out by the Rothamsted staff for East Africa.

An international organisation to combat crop and livestock pests and diseases, comparable to the World Health Organisation, was urged by E. C. Stakman, plant physiologist, University of Minnesota.

A source of disappointment to some delegates was the fact that delegates attended the conference as individuals rather than as government representatives, and that U.N.S.C.C.U.R. was not empowered to take action of any kind, even to the passage of a resolution urging the holding of further scientific meetings under the U.N. aegis. The conference closed with a series of meetings at which the discussions of the previous weeks were reviewed, and with the departure of a large group of foreign delegates on a trip to the Pittsburgh industrial area, the Department of Agriculture Research Centre at Beltsville, Maryland, and the Tennessee Valley as guests of the American Government.

Tractors and Implements in Action



Above: *A general view of the field demonstrations arranged by the Ford Motor Co. at Cranham, England.* Below: *A two-furrow deep-digger reversible plough in action. Note the walkie-talkie radio set*

THE most outstanding feature of the Ford machinery demonstration at Cranham, Essex, which took place recently, was the opportunity it gave of witnessing under field conditions the extraordinary flexibility and adaptability of the modern tractor. This versatility has resulted from the introduction of the tool bar with the hydraulic lift and tool bar equipment, of which a vast range is now available to the farmer. Tool bars can now be attached either to the front or the rear of the tractor and this greatly increases the number of uses to which it can be put.

Altogether some 49 different types of implements were shown at the demonstration. Apart from machinery for cultivation, a wide range of other forms of machinery was seen, including bulldozers and angle-dozers, scoops, winches, lifts and mole drainers, all of which can be mounted on or detached from the tractor as desired. There was also a number of new gadgets for use with the tractor, notably an ingenious and simple jack operated by the tractor itself, which enables the front or rear wheels to be lifted clear of the ground in a few seconds; a device, marketed under the name of the Holman ' Tractair,' which enables the tractor to deliver compressed air wherever wanted; and a transportable saw bench which is attached to the tractor lift and can be transported to the scene of its work in the raised position.

Of the many implements shown, special interest attached to the various types of the F-R two-way reversible plough first exhibited at the Royal Show this year, three models of which were shown, the single-furrow, the two-furrow deep digger and the two-furrow semi-digger. The new Fordson rotary root harvester also attracted attention.

Of particular interest to overseas visitors were the County Commercial crawler tractor, a full-track version of the Fordson Major, pulling a Ransome's five-furrow ' Dragoon ' disc plough, and the roadless D.G.4 half-track tractor, which is convertible to the wheeled form for rowcrop work and road haulage, pulling a Ransome's five-furrow ' Hexitrac ' plough.

The demonstration was extremely well organised, commentaries were given by a light van carrying loudspeaker equipment, which moved from point to point as the demonstration progressed, and through which the actual operators were enabled to comment by means of walkie-talkie equipment on the performances of the machines in their control.

In addition to the field demonstration, an exhibit was staged in a marquee illustrating the various aspects of the Ford training schemes, the service equipment and the export branches.

Here is a list of the equipment exhibited: F-R single-furrow reversible plough; F-R two-furrow deep digger reversible plough; F-R two-furrow semi-digger reversible plough; F-R two-furrow 14-in. deep digger plough; F-R single-furrow 18-in. deep digger plough; Fordson root harvester; Fordson transport box; Robot three-row potato planter; Paterson earth scoop; Scotmec hammer mill; Patrick and Wilkinson ' Lift Quik ' jack; F-R three-furrow 10-in. semi-digger plough; F-R three-furrow 12-in. deep digger plough; Fordson ' Elite ' three-furrow 10-in. general purpose plough, long controls; Ransome's four-furrow general purpose ' Multi-Trak ' plough; Ransome's five-furrow ' Hexitrac ' plough; Fordson tool bar with six bean seeder units at 18-in. rows (complete with marker and trip ropes); Fordson steerage hoe set for six rows at 18 in.; Martin mid-mounted tool bar (set for five 20-in. rows); Fordson beet lifter (static); Bamford mower; Paterson buckrake; ' Speedesi ' powder duster; Barford agricultural drainage machine;

Patrick and Wilkinson mounted mole drainer; Darlington heavy-duty winch; Darlington light winch; Cooke two-speed winch; spring-tine cultivator; Fordson rowcrop cultivator (set for 28-in. rows); rotary hoe; Patrick and Wilkinson harrow frame; Fordson ridger (28-in., complete with marker and trip ropes); Fordson front coverer (28-in. rows); F-R mounted potato digger; Patrick and Wilkinson sack lifter; 'Agro' atomiser (Ransome's); Patrick and Wilkinson 'Sprayquik'; Dening 'Master' saw bench; Holman 'Tractair'; Ransome's C.60 ridger; Ransome's C.60 steerage hoe; Ransome's five-furrow 'Dragoon' disc plough; Compton loader; muledozer; Tasker trailer; Markham 'Handiman' trailer; Markham hydraulic tipper; Stanhay hoist.

Rotary Root Harvester

THIS machine, which was introduced by the Ford Motor Co. Ltd. at the Royal Show this year, has been in use in this country since the beginning of the lifting season and has also been exported to many overseas countries.

It is a tool bar implement and is lifted and lowered by the hydraulic power lift which reduces turning time on the headlands and transport time from field to field.

It lifts two rows of sugar beet at a time and can be adjusted for row widths varying from 18 to 24 in. wide. The sugar beet must first be topped. Guide plates ensure that the beet are presented centrally to special lifting shares which lay them on a revolving spinner head.

The spinner head is driven from the power take-off shaft and revolves at a speed of 127 r.p.m. for a P.T.O. speed of 526 r.p.m. The drive is through a countershaft and an automobile-type crown wheel and pinion, which is completely enclosed in an oil bath and is fitted with special seals to prevent oil leakage. The spinner head itself revolves on six roller bearings and the gears and shafts are manufactured to fine precision limits.

The rotating spinner head serves the double function of cleaning the sugar beet and delivering them to two adjustable gates. These gates can be adjusted to windrow four rows of sugar beet into one. This minimises the time required for collection and also cuts down haulage costs.

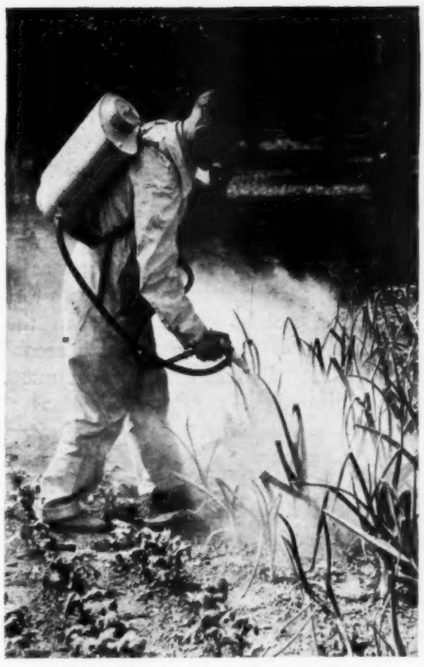
A simple attachment is being developed to adapt this harvester for lifting potatoes and all other root crops, thereby greatly widening its field of use on the farm. In addition, a simple topping device will be available.

The entire conversion kit can be quickly assembled to the tool bar in a few minutes by using ten bolts only. In addition, all adjustments for various row widths and soil conditions can be made very simply.

Depth is controlled by two pneumatic-tyred depth wheels, and the pitch of the implement is adjusted by means of the Fordson Major's top link.

New Dusting Aid for Small Farmers

THE greatly increased use of powder dusting to combat pests and disease is a striking development, but power equipment for the small and medium farmer to enable him to dust quickly and efficiently has not kept pace with the quickening interest in this method of pest control.



The portable dusting apparatus in action at Redditch, England. The machine has been tried out, it is said, with excellent results in India, South Africa and Argentina. The 7 lb. of powder used per acre, compares favourably with the 12 lb. normally consumed by hand blowers

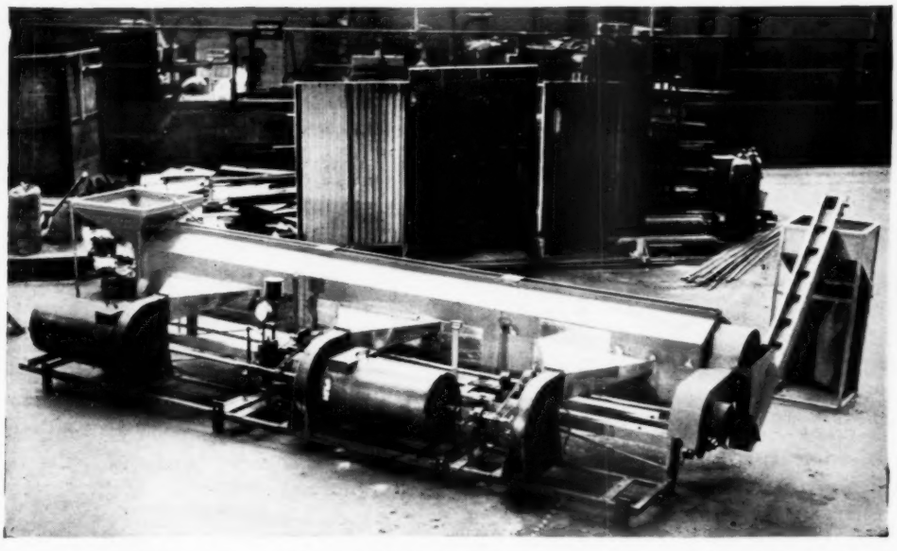
For this reason, interest attaches to a new compressed-air-operated powder dusting equipment, made and marketed by the Hymatic Engineering Co. Ltd. of Redditch, Worcs.

It consists of a lightweight knapsack powder container and a powder spraying pistol connected to a compressed air source. With an air pressure of 80 p.s.i. the pistol delivers a ¼ lb. of powder per minute. As the knapsack container holds sufficient powder for 80 minutes' operation at this rate, the equipment provides a big coverage.

In extensive field trials in South Africa, Argentina and India this blower has established itself as an efficient distributor of powder with satisfactory penetration. The field tests show that only 7 lb. of powder are used per acre as compared with 12 lb. consumed by hand-operated blowers.

The blower has proved well suited to operate with D.D.T., Gammexane and other powders, as well as with Agroxon which, containing lime, may burn the hands in damp weather if broadcast by hand.

In addition to crop dusting this blower is valuable for dusting livestock or buildings, particularly where food is stored and liquid spraying is impracticable.



GRAIN DRIER. *Last month we published a report on the demonstration of the new Oil-fired grain drier manufactured by Wells, Ltd. Here is a photograph of the equipment*

WORLD CROP REPORTS

U.S. Crop Forecasts are Second Largest

Further improvements in U.S. crop prospects now virtually assure the second largest total production on record, the Department of Agriculture says. In its latest report, based on conditions as of October 1, the Department predicts a total production nearly 1% larger than that indicated as of September 1, and second only to that of 1948. All crop output is now indicated at 131% of the 1923-32 base, exceeded only by the past year's 137%. The report observes: ' This huge out-turn is due to fairly large production of most individual crops, rather than record-breaking production of a few. Only rice and tree nuts promise record production, while maize and soya beans will be near record.'

The maize crop is estimated at 3,476,986,000 bushels (a U.S. maize bushel is 56 lb.). This estimate is down 1.4% from last month, but still is only about 5% less than last year's record.

Wheat production is put at 1,126,226,000 bushels (a U.S. wheat bushel is 60 lb.), slightly below the September 1 estimate, 13% less than the 1948 crop, but 14% more than the ten-year average. This year's total production consists of a winter wheat crop of 894,874,000 bushels (315,353,597 hectolitres) and a spring wheat crop currently estimated at 231,352,000 bushels (81,528,444 hectolitres). The spring wheat estimate was 2,855,000 bushels (1,006,102 hectolitres) less than that of a month ago.

The Department says that nearly 128,000,000 tons of feed grains will be produced this year, second only to the 137,000,000 in 1948. The report adds: ' With the record carry-over of maize and relatively large carry-overs of oats, barley and sorghum grain, feed supplies on farms will be the largest ever available, in both total and quantity per animal unit.'

The 36,500,000 tons of good grains now estimated, though exceeded in each of the three past seasons, is larger than in any earlier year, the report notes.

Current estimates on some of the major crops are:

Oats.—1,321,075,000 bushels (32 lb. to the bushel) up from last month's estimate.

Rye.—18,831,000 bushels (56 lb. to the bushel), virtually all harvested.

Barley.—234,025,000 bushels (48 lb. to the bushel). Harvesting of the crop, smallest since 1937, was virtually completed by October 1.

Groundnuts.—Production for picking and threshing estimated at 1,804,454,000 lb., 23% smaller than the 1948 record crop.

Tobacco.—2,004,214,000 lb., nearly one fifth more than average.

The Agriculture Department also forecasts a cotton crop of 13,446,000 bales of 500 lb. gross weight each. This is 503,000 bales more than the September 1 forecast, and would be 578,000 bales over the 1948 production. The ten-year average is 11,306,000 bales.

As now estimated, the cotton crop for this year will be the largest since 1937 and the fifth largest since 1920. The 1949-50 supply will be about 16% larger than the supply of last season and will provide the largest carry-over of post-war years.

Exports for 1949-50 are still uncertain, mainly because the cotton programme of the Economic Co-operation Administration, on which exports largely depend, has not been definitely settled. There are some indications, however, that U.S. cotton exports for 1949-50 will be somewhat lower than in 1948-49.

Australia's Big Wheat Harvest

The chairman of the Australian Wheat Board, Mr. F. H. M. Cullen, is optimistic about the prospects of the 1949-50 season. He says that recent good rains have ensured a normal harvest and further rains in October should lift the yield above the 190,000,000 bushels of last season. He says that rains have saved the crops in the Riverina in southern New South Wales, that the north-west Mallee area of Victoria expects a record harvest and that Queensland has sown a record acreage.

Farmers in New South Wales, which provides about one third of the Australian harvest, have sown an additional 250,000 acres this year. An extra 150,000 acres have been sown in Victoria and about 100,000 more in South Australia. Western Australia reports that its acreage has been reduced by 300,000 because of late rains, but wheat authorities there hope that the state yield will equal that of last year.

Australian Castor Beans

Promising results have been obtained in tests carried out in mechanical harvesting of castor beans in the Murrumbidgee Irrigation Area, proving that dwarf varieties of the bean are suited to mechanical harvesting by a header, provided that certain minor adjustments are made to the machine. Tests of Australian beans show that yields compare favourably with those of the main producing countries and are in the vicinity of 1,000 lb. per acre.

Wheat Harvest in Ethiopia

The Ethiopian harvest this year promises to be the largest in the history of the country. It is estimated that the exportable surplus will be between 200,000 and 300,000 tons.

The expansion of agricultural production is regarded as the key to general social betterment. The Government's vigorous agricultural development programme has brought about many improvements.

An Agricultural Bank is now supplying loans to the peasant farmer for the cultivation of crops and the raising of cattle. Model farms have been established in various parts of the country. These, as well as proving of instructional value, are used to provide selected seed for the peasants and to give a veterinary service to the locality.

Bumper Grain Crops in Iraq

Iraq has a bumper harvest this year. Wheat is expected to total 450,000 tons and barley 750,000 tons. In addition, the country has a carry-over of 100,000 tons of barley and 50,000 tons of wheat from last season's crops.

The use of mechanised harvesting has greatly assisted the gathering of these bumper crops, which are compared with those of 1942 which provided sorely needed grain for the Allied armies in the Middle East.

Her requirements of grain for the next year are put at 350,000 tons of wheat and 400,000 tons of barley. The Department of Agriculture is working towards diversifying the farming system of the country so that industrial crops will be grown to an increasing extent.

Sao Paulo Cottonseed Crop

The present cotton crop from the State of Sao Paulo should yield 360,804,813 kg. of cottonseed, of which 24,000,000 kg. would be put aside for planting, leaving 336,804,813 kg. to be milled for the extraction of edible cottonseed oil, excepting the oil produced from about 15,000,000 kg. of seed, which would not be fit for consumption.

Basing on the amount of seed already delivered to the oil refineries and still to be delivered, it is estimated that the total cotton crop will yield 28,396,162 kg. of cottonseed oil.

It is calculated that this will be insufficient for domestic necessities, and there will be no surplus for export.

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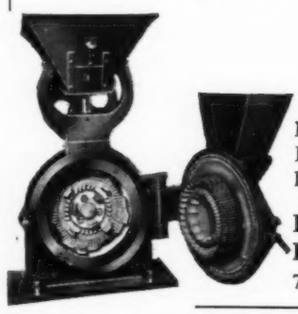

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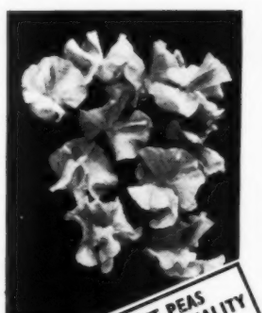

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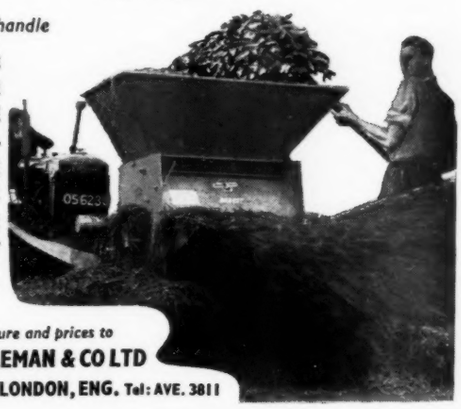

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